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of the

Railway Electrical Engineer

Vol. V. June, 1913, to May, 1914

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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The New P. R. R. Course in Electricity.

In our last issue we announced that the Pennsylvania Railroad had established a school of electricity for training its men in the fundamentals of electricity and magnetism. It now gives us pleasure to announce that through the courtesy of the officials of the Pennsylvania Railroad, we have been given special permission to publish this entire course as a series of lessons in the *Railway Electrical Engineer*. So this special training in electricity, which was designed for the education of Pennsylvania Railroad men, is now made available to all railroad men of the country.

This course will be published in addition to, and considered as entirely separate from, the two educational courses which we are now runnng: *Shop Motor Talks* and *A. B. C. of Railway Car Lighting.*

This makes a total of three strong correspondence courses, a complete lesson of which will be published in each issue. We feel that with the establishment of this new course, the *Railway Electrical Engineer,* is simply extending its policy of education and fundamental training which has been so successfully carried on for the past year, and we wish to take this opportunity to again thank our readers for their co-operation in making these courses a success by furnishing valuable ideas in our "Practical Stunts" column. Every railroad man in the country, interested in electrical matters, ought to take advantage of these courses in the *Railway Electrical Engineer,* but it is impossible to reach them all; if you will tell them about it, you will be doing them a favor, us a big favor and boosting the whole electrical game on railroads at the same time.

The Limitations of Standardization.

One of the most important factors in railroad operation after "Safety First" is standardization. It is absolutely necessary that all railroad equipment, at least insofar as parts that affect interchange of cars is concerned, be thoroughly standardized, and with this in mind much work of incalculable value has been done by the Committee on Standards of the M. C. B. Assoc. and A. R. E. E.

We must not attempt to carry this too far, however, for the moment we begin to standardize on the detail of all equipment, that moment we begin to go backward. There is a continual and a very rapid development in all branches of railroad equipment, and any cumbersome set of standards covering more equipment than absolutely necessary for interchange cannot but work a great hardship on the road that is endeavoring to keep abreast of the times.

The road that writes its specifications for cars largely by duplicating the "last order" soon finds itself installing out of date equipment. The policy of most progressive roads is to request the car builders to submit plans according to the most approved practice. Why shouldn't some such policy be incorporated into A. R. E. E. practice.

Purchase of Power for Electrical Operation.

One of the main problems confronting the railroads today when considering electrification matters is that of raising the necessary capital to finance such large undertakings as are involved. There are certain cases particularly in the hydro-electric developments of the Western mining districts, where the power companies can readily afford to furnish the railroads power at a rate considerably less than the railroads can

generate it themselves. The railroad power load will usually be an all day, 24-hour load, so that it will tend to improve the load factor of the power station that takes on such a load. But one of the most important points to be considered is that in such mining districts where a large amount of power is used by induction motors, the power factor of the generating station becomes very poor and the lagging component of the current furnished these motors involves a generator capacity and operating costs far in excess of what would be required to furnish the same amount of power at unity power factor.

It is well known that synchronous motors with strong excitation can be employed advantageously to give the proper leading component to balance up the lagging component of the induction motors. In fact, it often pays central stations and power companies to go to the expense of purchasing and installing large synchronous motors for this purpose and oftentimes these motors are used for no other purpose than to improve power factor by simply running idle at high excitation.

By a proper agreement for co-operation between railroad companies and power companies, synchronous motors in the railway sub-stations could be operated with great advantage to the power company. On this basis the power company could well afford to furnish power to railroad companies at sometimes even less than cost, for from the debit charge made for the amount of actual power furnished, the railway company must be credited with the value to the supply company of improving its power factor.

With such an advantageous arrangement for the generation of power, the railroad electrification problem would then be confined to one of sub-station equipment, rolling stock and power transmission equipment along the right-of-way.

Exposed Metal Work in Battery Rooms.

In the design of storage battery rooms it is very important that there be no exposed metal work, either conduit, open wiring or structural iron work. There is a double evil involved in this, particularly where the exposed metal is located above the battery, for the fumes will not only attack and disintegrate the metal, but the corroded metal scales will be very apt to drop into the open cells of the battery. It is well known, that even a very small percentage of copper or iron impurity in the electrolyte of a storage battery will very seriously damage the plates, causing them to discharge continuously due to local action.

The structural iron work of the building can be nicely protected by wrapping it with expanded metal lath, upon which a heavy coating of cement plaster is placed. If this is then well coated with a good asphaltum compound or lead paint, it will protect the structural work within very effectively. Where pipes and wiring do not come too close to the cells they can be easily protected with a heavy coating of some acid resisting paint. There is an excellent paint available for this purpose, which is very thick and heavy and forms a strong protective coating that is acid proof.

The battery rooms of all the new sub-stations of the N. Y. C. R. R. are painted with a preservative paint of this character. Conduit work and wiring which is in any way exposed to mechanical injury and at the same time located very near or below the cells where acid may spray or spill on it, should be well protected by a covering of sheet lead.

Indirect Illumination of Passenger Cars.

During the past few years, indirect illumination has been very extensively employed in our offices, homes and public buildings, and many of the newer stations and large railroad office buildings have been completely equipped for indirect illumination.

The application of this type of illumination to passenger cars has, however, been rather backward, partly on account of the somewhat lower efficiency of the indirect system resulting in an excessive load on the electrical equipment, and partly because of the fact that the monitor type of roof and ceiling does not lend itself very well to the application of the indirect system. However, numerous installations have been made from time to time and in fact a whole train has been equipped with indirect fixtures only recently.

Without doubt, as the turtle back type deck becomes more extensively employed, the possibilities of indirect illumination in railroad cars will be greatly improved, for this type deck provides a continuous reflecting and diffusing area, the curved surface of which will tend to increase the amount of useful illumination provided on the reading plane, and will minimize the amount of light reflected to the side walls where, by double reflection, it is largely absorbed before reaching the reading plane.

ASSOCIATION NEWS.

June Atlantic City Convention.

The official program for the semi-annual convention of the Association of Railway Electrical Engineers June 16th, has just been given out by Secretary Andreucetti, and is as follows:

Address of the President.
Consideration of minutes of last meeting.
Report of Secretary-Treasurer.
Unfinished business.
Report of Standing Committees.
Talk on "Illuminating Engineering Co-operation," by Mr. G. H. Stickney, representing the Illuminating Engineering Society.
Informal talk on "Gas-Electric Cars," by Mr. Samuel T. Dodd, of the General Electric Company.
Miscellaneous business.
Adjournment.

The headquarters of the Association are to be at the Hotel Dennis, and the meetings will be held in one of the large parlors of the hotel. The Secretary especially requests that all members of the Association make this hotel their headquarters and that they register as members of A. R. E. E.

The date of this convention comes right in the middle of the Railroad Convention week at Atlantic City, the Master Mechanics Convention being from June 11th to June 13th inclusive, and the Master Car Builders' Convention being held from June 16th to 18th inclusive.

The extensive display of exhibits on the Pier will afford the opportunity of seeing practically all the new devices and equipment on the market.

The Ampere Hour Meter in Car Lighting Service.

This is the title of a very attractive little booklet just issued by the Sangamo Electric Company of Springfield, Ills. This contains a reprint of the series of educational talks on this subject which appeared regularly in our advertising columns. A copy of this booklet is being sent each of the boys taking our Car Lighting course along with the instruction book of the Gould Company.

Railway Car Ventilation

Private Car of Mr. Geo. F. Baer, Pres. Philadelphia & Reading, Containing the Most Comprehensive System of Car Ventilation Ever Installed

The private car of Mr. Geo. Baer, president of the Philadelphia & Reading, which has recently been put into service, embodies the most approved practice known to the car builders' art today. It is one of the heaviest cars ever built and probably the most expensive, although there is nothing about the car that would give one the idea of extravagance or of needless expense. The whole idea in building this car has been with a view to safety and comfort and the general scheme of the interior is on lines of extreme simplicity. Each of the various rooms is finished in a different kind of wood; satin-wood, Mexican mahogany, white mahogany, bird's-eye maple, quartered oak and mosaic tile all being used with artistic graining effects.

Fig. 1. Interior of Observation Room. (Note Ventilation Duct in Bulkhead Near Ceiling.)

Steel construction is used throughout with the exception of the interior trim, there being three heavy steel transverse bulkheads of 5/16 in. plate steel forming the partitions between the various sections of the car. This greatly reinforces the car body.

Special attention has been given to the matter of heat insulation and ventilation, so as to preserve a uniform temperature so far as possible, with fresh air at all times, whether standing or on the road. The ventilation system was designed by Mudge & Co., of Chicago, and is without doubt the most comprehensive system of railway car ventilation ever installed; in fact, it embodies the good points of numerous older ventilation systems of merit, yet seems to make up, to a large extent, for the deficiencies of each. In addition to the usual exhaust ventilating system, there is a fresh air intake provided so that fresh and fairly clean air, warmed in the winter time, and at outside temperature in the summer, will be provided at all times, whether the car is in the station or on the road.

The car is provided with four different types of ventilating units as indicated on the accompanying diagrams. These are the standard Garland ventilator type A, the center deck roof Garland ventilator type C, the motor driven blower with auxiliary Garland ventilator exhaust set and a special air intake ventilator. There are 13 of the standard type A ventilators located on the quarter deck at various points in the car as shown in the diagram. These provide for ample exhaust in all sections of the car when the car is in motion. A center deck type C ventilator is mounted in the roof of the kitchen as there was not sufficient room on the quarter deck to locate a standard type A ventilator in addition to the blower set with auxiliary exhaust ventilator.

This blower exhaust ventilator is suspended from the car roof as shown in Fig. 3, and consists of a combination of a motor driven blower of the multi-

vane Sturtevant type and exhausts into an auxiliary exhaust Garland ventilator as shown. There is an auxiliary exhaust chamber provided above, which provides an additional exhaust duct when the train is in motion and the Garland ventilator operating. It should be

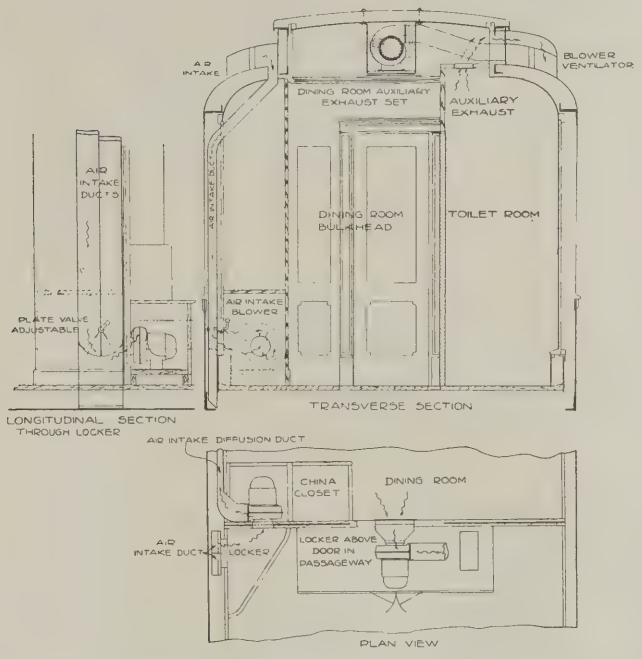


Fig. 2. Sectional Views and Plan Showing Positions of Air Intake Blower and Also Exhausting Blower.

noted that this ventilator combines the principle of the blower exhaust with that of the standard Garland ventilator without interfering with, or reducing action of either type. As a matter of fact, the air driven through the ventilator by the blower while the car is standing still, actually induces an added flow of air through the auxiliary exhaust opening of the Garland ventilator and increases the efficiency of the blower set about 15 per cent. This is accomplished by means of a curved lip at the point where the auxiliary chamber

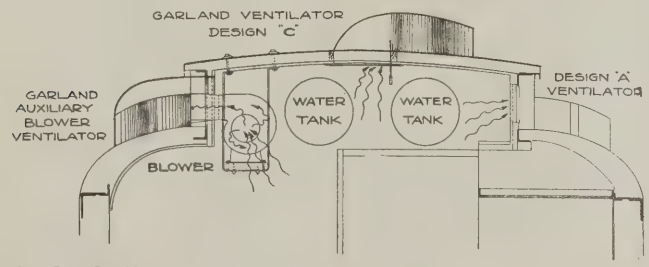


Fig. 3. Sectional View Showing Construction of Three Different Type Ventilators.

opens into the main exhaust chamber. This creates a whirling motion in the blower exhaust which draws the air from the auxiliary chamber above.

When the car leaves the station, the ventilator becomes effective and increases the blower exhaust, but upon reaching critical speed of the axle generator equipment, the motor is automatically cut off and the blower ceases to operate. Thereafter, however, until the next stop, very effective ventilation is maintained by the Garland ventilator acting both through the auxiliary exhaust chamber and through the blower itself. Each of these blower ventilators is rated at 33,000 cubic feet of air per hour when the blower alone is operating. With a train at a speed of 50 miles per hour, the ventilator alone has a capacity of approximately 24,000 cubic feet of air per hour. There are four of these motor driven blower exhausts, one located in the kitchen, one behind the grille over the dining-room, another exhausting the private room and bath room, and the other exhausting both staterooms and the observation room. These ventilating sets are all of the same design as shown in the accompanying illustrations although the auxiliary exhaust chamber is connected with certain adjoining rooms in each case; the dining-room ventilator also ventilates the adjoining toilet-room through the blower exhaust, that in the private room also exhausts the bath-room and the blower in the observation room also exhausts the two adjoining staterooms through its auxiliary exhaust. In each case the blower is suspended from the car roof trusses and is in an out-of-the-way and well concealed position.

The blower, however, is designed with particular reference to inspection and repairing, for by simply

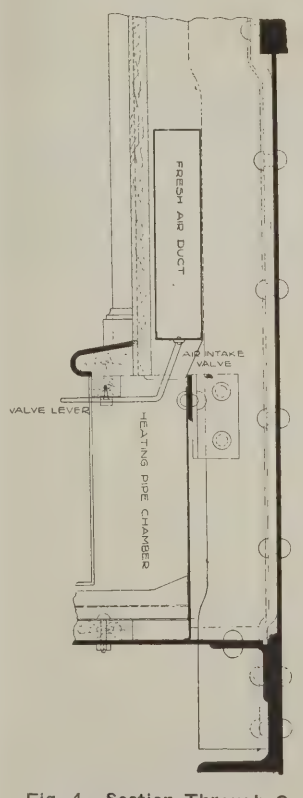


Fig. 4. Section Through Car Wall Near Floor Line.

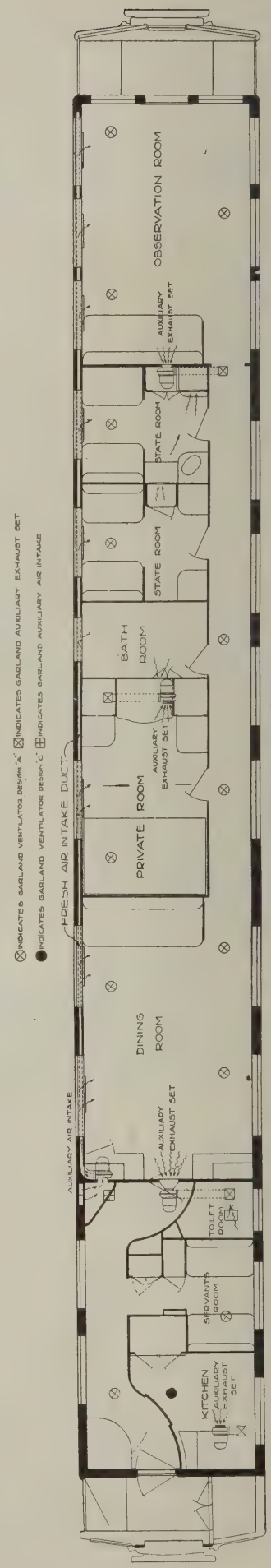


Fig. 5. Plan View of the Car.

unscrewing a couple of thumb screws, the blower vane element may be removed and cleaned, and similarly, by loosening two small bolts the entire motor may also be removed without disturbing in any way the connection to the exhaust, if repairs are necessary.

A motor driven blower set is also employed to provide fresh air to the car when standing still and an especially designed intake ventilator of the Garland principle is operative when the car is on the road, the blower set being then shut down. Air is drawn from the special intake ventilator located on the quarter deck as shown at the left of the sectional diagram, Fig. 2. When the car is at rest the motor blower set is operating and when the car is in motion the action of the air striking the ventilator vanes causes a down draft of considerable force through one of the air intake tubes, depending upon which way the car is moving.

In order to prevent rain, cinders, etc., from entering the intake chamber, the baffle plate at the outer edge of the ventilator, which re-directs the blast of air downward into the intake tubes, is raised slightly so that there is a clearance of about one inch between it and the car roof. This provides that the biggest part of the rain and cinders is permitted to pass directly out of the ventilator. A small drain opening of about ½ in. is provided at the lower end of this ventilator intake duct, however, so that in case there is any quantity of fine cinders or water that finds its way into the duct run, it will simply drain out at the bottom.

A balanced valve is provided at the bottom of this double intake duct which operates automatically on reversal of car motion, for obviously, in order to prevent the air coming down through one duct and simply exhausting out through the other, only one of the two ducts must be operated at a time. There is also a hand operated damper provided which makes it possible to completely shut off the air intake system as desired.

By providing a special air intake system, as is done in this car, the vacuating effect of the Garland exhaust ventilators is largely balanced so that the air within the car is at approximately the same pressure as the air outside. This will prevent the entrance of air through dusty vestibules or other unsanitary openings.

Fig. 6. Interior of Dining Room. (Note Ventilating Duct Over Doorway.)

The exhaust from this blower intake set feeds down through a duct run 2x9 inches in section. This is located in the car wall just above the steam heating pipes and there is one or more outlets into the steam coil chamber in each of the rooms. These outlets are controlled by an intake valve which is adjustable to suit requirements as desired. In the winter time when the heating system is operating, this incoming current of cold fresh air will be thoroughly heated before entering the compartments. It is found on cars recently placed in service that this air intake system operates very effectively, delivering fresh air into the observation room which is farthest from the blower, in almost as great a volume as in the dining room, although no definite test data is available on this point at the present time.

The car is electrically lighted and is equipped with a 4-k.w. type C, 30-volt Gould Generator. Two sets of Gould batteries of 16 cells each are connected directly in multiple. These batteries are of the 15-plate Plante type and have a capacity of 384 ampere hours each, or 768 ampere hours in multiple.

The lamp and motor load of this car is very heavy, requiring approximately 75 amperes, 2,400 watts to properly illuminate and ventilate the car. There are two lamp regulators provided, each of which carries

half the total lamp load, the motors being connected directly to the battery, as voltage regulation is not necessary, in fact, undesirable, for this motor load.

The generator is set to operate at 5 k.w. or 125 amperes with all lamps and motors turned on, and about 100 amperes with all lamps and motor load off. The two batteries will then be charging in multiple, the current dividing approximately 50 amperes per battery.

present a most attractive appearance. This electrical installation includes every improvement in design and construction known to the car lighting art of today.

The car lighting fixtures are clearly shown in the accompanying illustrations and it will be seen that these are of the enclosed, diffusing bowl type. The soft opal glassware in the observation car and the art glass panels in the dining car fixtures, however, present

Fig. 7. Private Car of Mr. Geo. F. Baer, President of the Reading.

This installation is particularly interesting to the car lighting man on account of the extremely heavy load it carries.

To be in keeping with the high grade construction throughout the rest of the car, all of the electrical apparatus and panels of this car, including the ten circuit switchboards, were given a high degree of finish and a very pleasing appearance. The fixtures were installed by the Safety Car Heating and Lighting Co.

The heating system is a combination steam and hot water furnished by the Safety company and is used in connection with a Baker fireproof heater when cut off from the locomotive. The various rooms in the car can be heated independently of each other.

High Voltage Direct Current Locomotives

Butte, Anaconda & Pacific Railway Electrified for Operation on 2,400 Volts Direct Current Between Butte and Anaconda, Mont., Placing in Service Fifteen Freight and Two Passenger 80-Ton Electric Locomotives

The electrification of the Butte, Anaconda & Pacific Railway is of exceptional interest because it represents one of the largest installations of electrical equipment for steam railroad service and the first in this country where direct current locomotives operating on as high a potential as 2,400 volts will be employed. Construction work necessary to effect the change from steam to electric equipment is now practically completed, and at the present writing it is expected that the road will start operation as an electric system about June 1, 1913.

The adoption of the 2,400-volt direct current system for this railway was determined after a comprehensive study of local conditions and requirements. The traffic demands are unusually severe and consist principally of hauling long trains of copper ore over heavy mountain grades. In comparison with other existing systems, the 2,400-volt direct current system was considered best suited for exacting service of this character; for its adoption presented an opportunity to realize unusual economies both in initial expenditure and the cost of operation.

The section of the road that has been equipped lies between Butte and Anaconda, Mont. It comprises 30 miles of main line single track, and numerous sidings, yards and smelter tracks, aggregating a total of about 90 miles on a single track basis. The haulage of copper ore from the Butte mines to the smelters at Anaconda, together with all mine supplies, lumber, etc., moving in both directions, amounts to practically 5,000,000 tons of freight per year. Complete freight trains weighing 3,400 tons are made up of fifty loaded steel ore cars and will be handled against a ruling grade of 0.3 per cent by a locomotive consisting of two units. Single units will be used for making up trains in the yards and for spotting cars.

The initial equipment consists of seventeen locomotive units, Type 0440-E-160-4 GE 229A, fifteen for freight and two for passenger service. Each unit weighs approximately 80 tons. The two units for forming the freight locomotives in each case will be coupled together and operated in multiple unit. The combination freight locomotives will haul the usual trains of 3,400 tons at a maximum speed of 15 miles per hour against the ruling grade and at 21 miles per hour on level tangent track.

The passenger locomotives are the same design as the freight locomotives, except they are geared for a maximum speed of 45 miles per hour on level tang-

ent track. A schedule of eight passenger trains per day, four each way, is maintained, the average train being composed of a locomotive and three standard steam road passenger coaches. All the locomotive equipment, as well as the substation apparatus and overhead line material, was designed and built by the General Electric Company. One of the locomotives will be on exhibition on the Mississippi Avenue track at the Master Mechanics' and Master Car Builders' Conventions, Atlantic City, N. J., June 11 to 18 inclusive.

The locomotives are the articulated double truck type with all weight on the drivers. The cab, containing an engineer's compartment in each end and a central compartment for the control apparatus, is carried by the two truck frames on center pins. It is the box type, extending the entire length of the locomotive, and is provided with end and side doors. On each axle is mounted a motor of the twin geared type. The friction draft gear mounted on the outer end frame of each truck transmits the hauling and buffing stresses directly through the truck frame, diverting these strains from the center pins and underframe.

The trucks are built of heavy steel castings. The side frames are of a truss pattern with heavy top and bottom members and pedestal tie bars. They are connected by end frames and a cast steel center transom. The entire weight is carried on semielliptic springs suitably equalized.

The cab underframe consists of two 12-in. longitudinal steel channels on either side of the center and two 6-in. by 6-in. steel angles along the outer edges. The central channels are enclosed and form a distributing air duct for forced ventilation. Air is conducted through the center pins, which are hollow, into the truck transoms and thence to the motors.

The engineer's compartment, at either end of the cab, contains the operator's seat, controller, air brake valves, bell and whistle ropes, ammeter, air gauges, sanders and other control apparatus that should be within immediate reach of the engineer. These compartments are comfortably heated by electric heaters.

In the central section is grouped the control apparatus. The contactors, reverser and rheostats are mounted in two banks running lengthwise of the compartment and are arranged with ample space between them to afford convenient access for cleaning, inspection and repair. All parts and circuits carrying 2,400 volts are thoroughly protected from accidental contact. A dynamotor is employed to furnish 600 volts for the operation of the contactors, lights and air compressor.

The principal data and dimensions applying to the locomotives are the following:

Length inside of knuckles	37 ft. 4 in.
Length over cab	31 ft.
Height over cab	12 ft. 10 in.
Height with trolley down	15 ft. 6 in.
Width over all	10 ft.
Total wheel base	26 ft.
Rigid wheel base	8 ft. 8 in.
Track gauge	4 ft. 8½ in.
Total weight	160,000 lbs.
Weight per axle	40,000 lbs.
Wheels, steel tired	46 in.
Journals	6 in. by 13 in.
Gears, forged rims, freight locomotives	87 teeth
Gears, forged rims, passenger locomotives	80 teeth
Pinions, forged, freight locomotives	18 teeth
Pinions, forged, passenger locomotive	25 teeth
Tractive effort at 30 per cent. coefficient	48,000 lbs.
Tractive effort at one hour rating	30,000 lbs.
Tractive efforts at continuous rating	25,000 lbs.

The motors are the GE-229A commutating pole type, wound for 1,200 volts and insulated for 2,400 volts. A forged pinion is mounted on each end of the armature shaft and meshes into a corresponding gear mounted on the wheel hub. The gear reduction is 4.84 on the freight locomotives and 3.2 on the passenger locomotives.

The GE-229-A motor is designed especially for locomotive service, is enclosed and provided with forced ventilation. Air is circulated over the armature and field coils, over and through the commutator, through longitudinal holes in the armature core, and thence exhausted through openings in the bearing head. This method of ventilation circulates effectively a large volume of cool air throughout the motor and keeps all parts at a uniform temperature, eliminating the possibility of "hot spots."

The continuous capacity of each motor is 190 amperes on 1,200 volts under forced ventilation, and 225 amperes on 1,200 volts for the one hour rating. For the double unit 160-ton locomotive this is equivalent to a continuously sustained output of 2,100 horsepower.

The control equipment on the locomotives is the well-known Sprague-General Electric Type M multiple unit control, and is designed to operate the four motors in series and series-parallel. The pairs of motors with their respective resistances are all connected in series on the first point of the controller. The resistance is varied through nine points on the controller and finally short-circuited on the tenth or running point. The pairs of motors are then operated similarly in series-parallel and all resistance is cut out on the nineteenth point, which is the full speed running point. This provides a control with ten steps in series and nine steps in series-parallel.

The transition between series and series-parallel is effected without opening the motor circuit, and there is no appreciable reduction in tractive effort during the change. The smooth transition between control points permits acceleration close to the slipping point of the wheels. A switch is provided having manually-operated handles for cutting out either pair of motors, so that the locomotive can then be operated with one pair of motors in the usual way.

The contactors are actuated by the 600-volt circuit obtained from the dynamotor and are of a design similar to that employed in the standard Type M control. The principal variations are embodied in the method of insulating for the higher voltage. The arm between the operating armature magnet and the arc chute mechanism consists of a treated wood spacer insulator; and the contacts and magnetic blowout, which make and break on the 2,400-volt circuit, are mounted on mica and porcelain insulators.

The main switch is provided with a powerful blowout so that heavy currents can be opened. The three smaller switches, one for each of the two heaters and one for the dynamotor circuits, are designed, specially for 2,400 volts. The blade is controlled by a lever attached to the grounded part of the locomotive frame and insulated from the live parts of the switch by a rod of treated wood.

There is one main fuse for the trolley circuit and two fuses for the motor circuits. They are all of the copper ribbon type and are fitted with hinged covers to facilitate fuse renewals. The boxes are located as near as possible to the overhead trolley in order to protect the wiring circuits near the source of supply. There is also an auxiliary circuit fuse for protecting locally the dynamotor and heater circuits. The main,

motor and auxiliary fuse boxes are provided with powerful magnetic blowouts, energized by current passing through the fuse, to insure proper rupture of the arc.

An ammeter is located at each engineer's position and indicates the current in the circuit of one pair of motors. The ammeter and air gauges are illuminated by a gauge light connected in the headlight circuit, so that the headlight switch turns on simultaneously the headlight and gauge light at the same end of the locomotive.

The main motor rheostats are formed of cast iron grids assembled in a frame and insulated by mica. Twenty resistance units are provided for each passenger locomotive, and twenty-six resistance units for each freight unit. The rheostat boxes are mounted in an enclosed compartment above the banks of contactors.

Current is collected by overhead trolleys of the pantograph type. They are pneumatically operated and can be put into service from either engineer's compartment by a hand-operated valve. Each passenger locomotive is equipped with two collectors, and each freight unit with one collector. A 2,400-volt insulated bus line connected direct to the pantographs is run along the center on the roof of the cab. The bus lines are connected by couplers between the two units of the freight locomotive, so that current is obtained from both collectors or from a single collector. The collectors and bus lines are adequately guarded by railings.

The locomotives are equipped with arc headlights. The interior illumination of the cab is provided by ten incandescent lamps arranged in two circuits, one lamp being placed in each engineer's cab and the balance in the central compartment. In each lamp circuit is a portable lamp with an extension cord. One lamp switch is located in each engineer's cab, so that one lamp circuit can be controlled from each end of the locomotive. A 600-volt bus line is provided on the passenger locomotives for lighting and a 2,400-volt bus line for heating the passenger coaches.

The air brakes are the combined straight and automatic type. The air compressor, of the CP-26 type, is two-stage, motor driven, and has a piston displacement of 100 cu. ft. of air per minute when pumping against a tank pressure of 135 lbs. per square inch. Air is taken from the interior of the central compartment through a screen, which prevents the entrance of particles of dust. The compressed air in passing from the low pressure to the high pressure cylinder is conducted through radiating pipes on the roof of the cab. This reduces the temperature of the air and allows condensation of moisture before entering the high pressure cylinder. From the high pressure cylinder it is delivered into four air reservoirs, each 12 in. by 164 in. They are located under the floor of the cab and connected in series, which affords a further opportunity for radiation and condensation.

Pneumatic sanders are provided. The sander valves are located within convenient reach of the engineer's seat, and vales and boxes are arranged for sanding the track in front of the leading wheels when running in either direction. The couplers are M. C. B. standard. The bells are fitted with automatic bell ringers, and the whistles are air-operated. All wiring is drawn through conduits and carefully protected from possible mechanical injury.

NOISELESS GEAR DRIVING.

A 56-page book issued by the New Process Gear Corporation, Syracuse, N. Y. contains some sound engineering arguments for rawhide gears, proves that they are of important economic value in any plant where high speed gears are used, gives much transmission data, and is profusely illustrated with photographs.

STEAM TURBINES WITH EXHAUST DISCS.

There is a certain pressure limit beyond which a steam turbine ceases to benefit by further expansion. It has been pointed out by a French engineer, however, that if part of the steam is removed to the condenser at that pressure the remainder can be expanded within the turbine to advantage. Acting upon this idea a turbine has been constructed with an additional

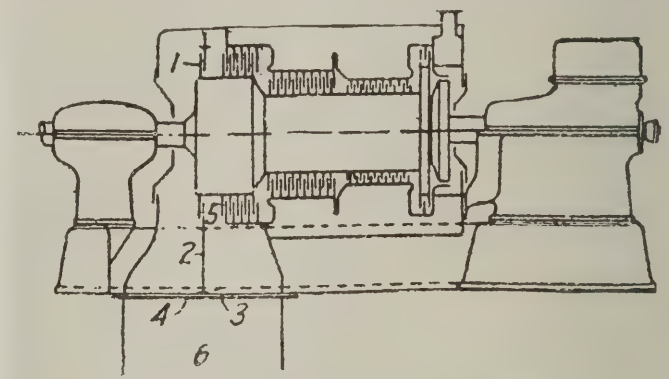


Diagram of Turbine with Exhaust Discs.

set of blades called the exhausting discs. These are labeled (1) in the accompanying illustration. Approximately, 60 per cent of the steam is passed, the balance being diverted into the condenser (6) by the diaphragms (2) and guide blades (5).

By this means nearly 4 per cent additional power is obtained and a still further improvement in efficiency has been obtained by extending the diaphragm (2) so as to divide the condenser into two chambers; the pressure in compartment (4) is then slightly lower than that in compartment (3). An increase in efficiency of 6.8 per cent has been reported where this device has been employed.

THE SALESMAN'S CREED.

I believe in my job, I believe in my firm, I believe in my goods, I believe in myself.

The interests of My House are my interests—its friends are my friends.

I serve My House, but to serve it best, I must serve my customers honestly and well, for they are the friends of My House.

I honor My House for its principles—

The principle of Integrity.
The principle of Fairness.
The principle of Progress.
The principle of Strength.

I believe My House is founded upon the bedrock of Square Dealing with its customers and with its salesmen. With such principles behind me what can stand between me and success?

I believe that the products of My House are important factors in the general prosperity and that in selling these products I am doing a useful and a good work.

I believe that every sale I make benefits the buyer equally with myself.

And so I am proud of my work, of My House, of my product. I shall not allow the misrepresentation of others to abate that pride, nor a lessening of my own energy and loyalty to detract from the results, to which My House and I are entitled.

My House trusts me.

Shall I prove unworthy of that trust?

Editor's Note:—The above is taken form a poster issued by the American Pulley Company, and is a creed to which every salesman might well subscribe.

Electric Arc Welding in Railroad Shops

GEO. W. CRAVENS

The use of the electric current for joining metals has been practiced for many years and, when electric welding is mentioned, most people think of either the butt-welding or the spot-welding processes. This is because these two variations of the "resistance" method have been in wider general use for a longer period than the other or "arc" method of welding. And this is strange because the arc method is much more universal in its applicability than the other method.

The resistance or "incandescent" method is the one used frequently for welding track rails, tires, chains, bars, pipe, sheet-metal and other articles by passing a current through the point of contact between the

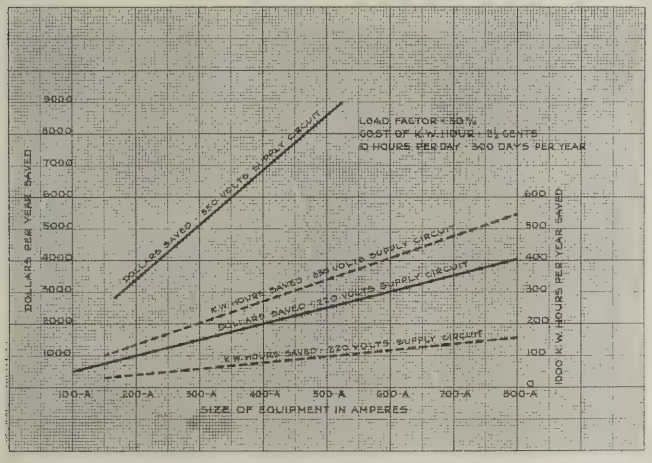

LOAD FACTOR - 50%
COST OF K.W. HOUR - 1½ CENTS
10 HOURS PER DAY - 300 DAYS PER YEAR
DOLLARS SAVED - 550 VOLTS SUPPLY CIRCUIT
K.W. HOURS SAVED - 550 VOLTS SUPPLY CIRCUIT
DOLLARS SAVED - 220 VOLTS SUPPLY CIRCUIT
K.W. HOURS SAVED - 220 VOLTS SUPPLY CIRCUIT
DOLLARS PER YEAR SAVED
1000 K.W. HOURS PER YEAR SAVED
100-A 200-A 300-A 400-A 500-A 600-A 700-A 800-A
SIZE OF EQUIPMENT IN AMPERES

Fig. 1. Showing Saving Effected by C. & C. Welding System.

parts to be joined, and depending upon the resistance of the joint to heat the metal. When the temperature rises high enough to soften the metals, pressure is applied and the parts are squeezed together sufficiently to cause them to unite. This process is fairly efficient in the comparatively narrow field in which it is applicable, but is limited almost entirely to the production of new articles of moderate size and is seldom used for repair work.

The arc welding process, on the other hand, can be used for new work and repair work both, and is adaptable to cutting apart, filling in or building up parts, as well as joining them. There are three methods of using the electric arc for welding (using the term in its present-day sense), each taking the name of the man who did the most to develop it. These are the Zerener, Bernardos and Slavinoff processes, the two latter being the most practical and the ones which will be described here. Both are used quite extensively in America today, in railroad and other machine shops.

The Zerener process consists in arranging the positive and negative electrodes in a holder in such a way that the carbon electrodes form a "V," the craters being downward and between the jaws of a very powerful electromagnet which acts as a sort of "blow-out" and causes the arc to be distended downward toward the work. The result is to cause the arc to act very much as a gas torch, but it is so sensitive and inefficient that this process is not used in this country so much as abroad. The electrode holders are heavy and complicated and interfere to a large extent with the operator, and are easily thrown out of repair, but this type is used to some extent for small work in steel and brass and for tubes and tanks having small corners.

The Bernardos process consists in drawing the arc between the work and a single carbon or graphite electrode, the electrode holder being made as small and light as practicable for the amount of current required. The arc is drawn by touching the graphite electrode to the work and drawing it away the proper distance, similar to the action of an arc lamp when starting, and then using the temperature of the arc (about 4000° C.) to fuse the filling metal into place. This method of using the electric arc is the best known and most widely used and is especially suitable for large and heavy work, such as the steel side frames

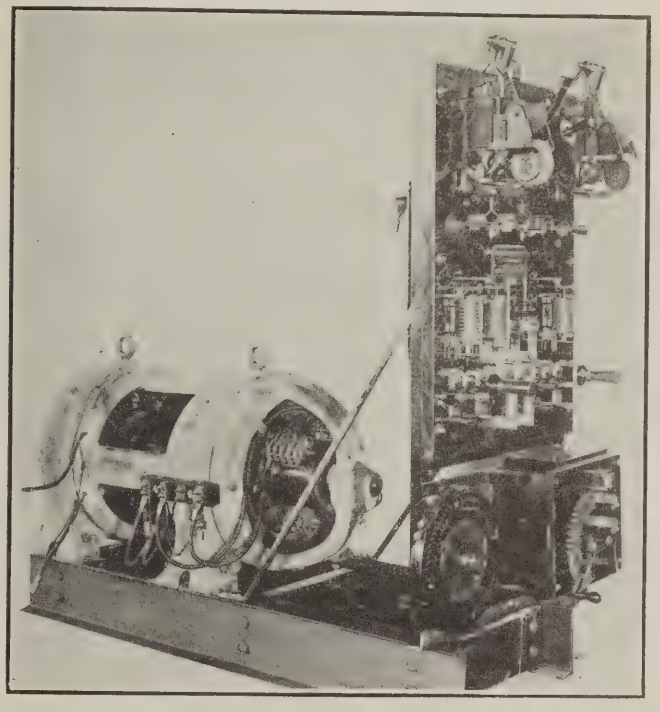


Fig. 2. C. & C. 300 Ampere Arc Welding Outfit.

of steam locomotives, steel castings, etc., although it is not limited to that class of work by any means. In fact, by using a small electrode and cutting down the amount of current, it is almost as universal in its application as the Slavinoff process.

The Slavinoff process consists in using the work as one electrode and a piece of the filling metal as the other, the latter being put into a suitable holder similar to those for the graphite electrodes. The arc is drawn by touching the work with the electrode and drawing away, as with the carbon, but the filling in is done by the melting of the electrode itself. Owing to the peculiar action of the arc, the metal from the electrode is carried onto the work in a direct line, so it is possible to work overhead or on a vertical wall as well as on horizontal surfaces. This is very convenient when repairing or joining large or heavy pieces which cannot easily be moved. This also makes it possible to repair machines in many cases when it is not desirable to take them to pieces, such as locomotive boilers.

With both the Bernardos and Slavinoff processes

the work is made the positive terminal of the line and the electrode the negative. It is well known that the positive crater of an arc lamp is much hotter than the negative, and this fact is taken advantage of when using the arc welding system in order that the work will be at a sufficiently high temperature to insure the proper joining of the filling metal. It will readily be seen that this process is very similar to soldering, excepting that the filling material is of practically the same composition as the article worked upon. The difference in the two materials, work and filler, must be such as to leave the weld of the same hardness, and to do this the proper electrodes must be obtained. The makers of the various welding equipments can supply the proper filling materials for any class of work. Only a few classes of work require fluxes to insure a good job.

Owing to the very sensitive nature of the electric arc it is of great importance that the source of current supply be controlled as positively as possible, so experience shows that a motor-generator set is the best means of getting good regulation of the supply. This also makes it possible to operate welding outfits from alternating current feeders, because a direct or continuous current is required. The use of a single machine, such as a dynamotor on direct current lines

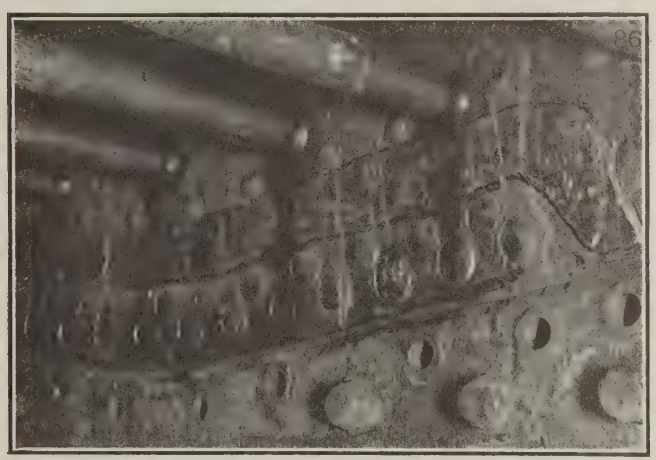


Fig. 3. Patch in Locomotive Boiler with Seam Prepared for Welding.

or a rotary converter on alternating current lines, has been tried but with indifferent results on account of the poor regulation and the impracticability of operating more than a single circuit.

The best results with arc welding have been obtained at from 60 to 65 volts, and where this reduction is obtained with resistances instead of from a low voltage generator there is a great loss of energy and very low efficiency. The accompanying curves, Fig. 1, show the relative efficiencies of the resistance and low voltage generator methods, as determined by the C. & C. Electric & Mfg. Co., the largest manufacturers of arc welding apparatus in America. This is plotted to show the saving in dollars per year by using the low voltage method for different capacities of apparatus, and it will be easy to see that such an outfit will soon pay for itself in current saved.

The outfits for arc welding on the market today in this country are for operation on either the Bernardos or the Slavinoff methods or a combination of the two. The Westinghouse Co. has been using the Bernardos method in its own shops with resistance in series to cut down the voltage until recently; the Siemund-Wenzell Co. uses the Slavinoff method with a low voltage generator; the C. & C. Electric & Manufacturing Co., Garwood, N. J., manufactures an outfit for use on both the Bernardos and Slavinoff methods, using a low voltage generator with a motor suited to the current supply circuit; and the Electric Welding Materials Co. has a single unit machine made by the Lin-

Fig. 4. Ear of Throat Sheet Welded. (This Saved Entire New Sheet.)

coln Electric Co. which operates on both methods, but cannot be used on alternating current circuits.

The accompanying illustrations, Fig. 2, shows a C. & C. outfit for use with both graphite and metallic arc welding, and the equipment on the panel is provided to give entirely automatic control of the weld-

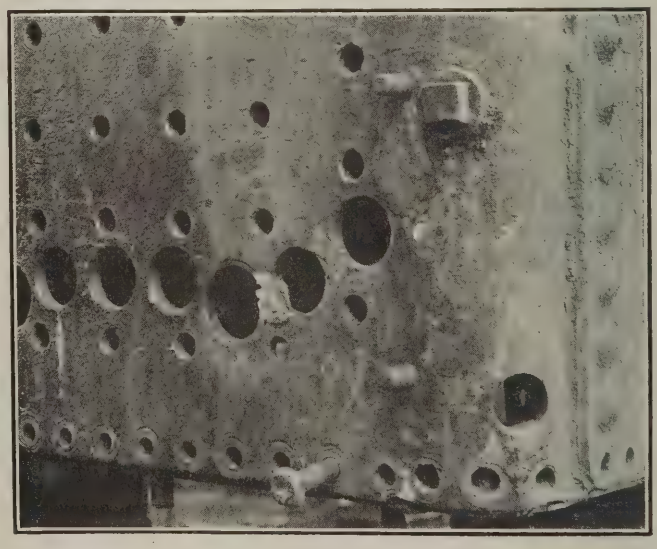


Fig. 5. Bridge in Flue Sheet Welded, Ready for Dressing. (One of the Hardest Jobs to Do Right by Any Other Process.)

ing circuits. With this outfit any number of operators may be supplied from one generator by simply adding enough controlling apparatus to the panel. Where panels and sets are already installed, it is only necessary to get additional small panels with suitable equipment for controlling either graphite or metallic operation and carrying long leads to the main panel. The small panels can be located in any desired posi-

tion with relation to the main board, and in some cases these have been made portable by mounting on small trucks for moving around the shops. Where conditions warrant, the entire welding outfit has been

Fig. 6. Broken Engine Frame, Lower Member, Before Welding.

made portable in the same way and has proved a very great money-saver.

For shops in which rapid production and low cost are necessary, together with high quality of work, such as in railroad shops, it is of the utmost importance that the welding apparatus should be simple and easy to operate, as nearly automatic as possible, require no

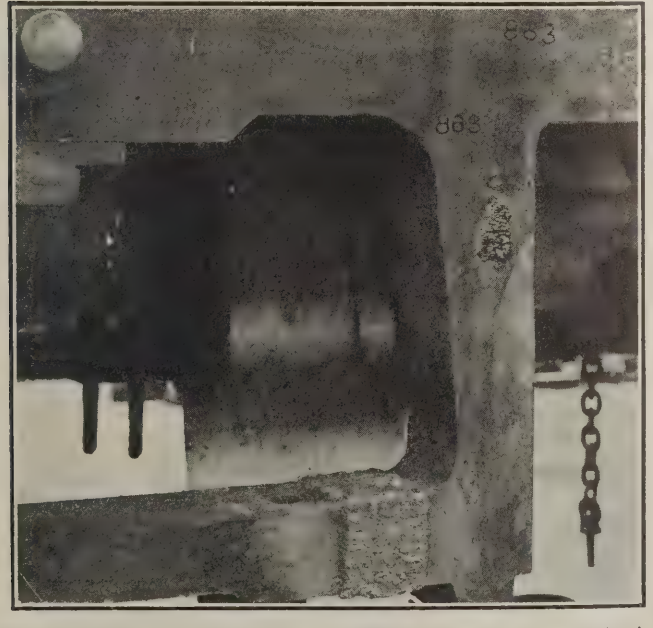


Fig. 7. Same as Above After Welding with Metallic Electrode. Ready to Dress Off.

attention during the course of a piece of work, have no water boxes or other voltage reducing devices (other than those necessary for the accurate regulation of the current, at the switchboard) and of the

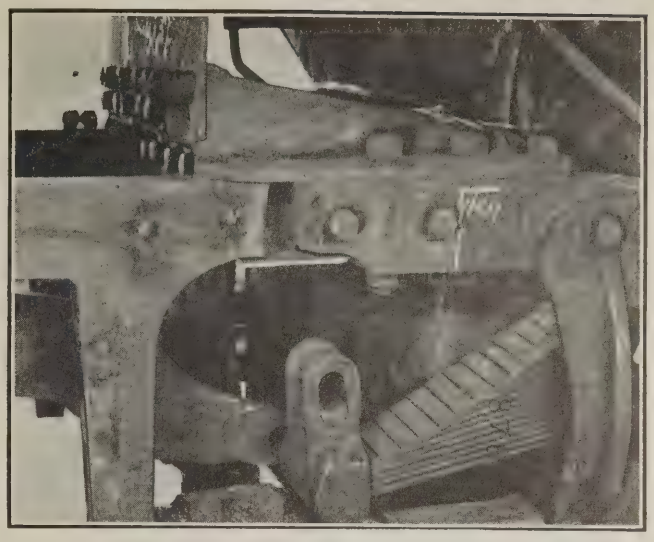


Fig. 8. Broken Engine Frame Upper Member, Cut Away with Carbon Arc. Ready for Filling.

highest over-all or working efficiency. It is results that count. The outfits supplied by the best makers consist of the motor-generator, controlling panel, electrode holders, head and hand shields for the operators and a supply of electrodes. The head shields have a window of red and blue glasses to protect the eyes of the operator from the blinding glare of the arc. The combination system outfit includes a patented combination electrode holder for taking both a graphite and a metallic electrode, so it is possible to change from one to the other method by simply throwing a switch on the holder.

With the Bernardos system, using a carbon or graphite electrode, the current required will range from 100 to 600 amperes per circuit, and with the Slavinoff system, using metallic electrodes, the current will vary from 25 to 200 amperes, depending upon the nature of the work, the size of the piece being manipulated and the material. The usual operations with the metallic electrode, however, require but from 50 to 100 amperes, and with the graphite electrode from 200 to 300 amperes, the latter being used for cutting purposes frequently.

The following figures show the cost of several actual jobs done with the electric welding arc outfits,

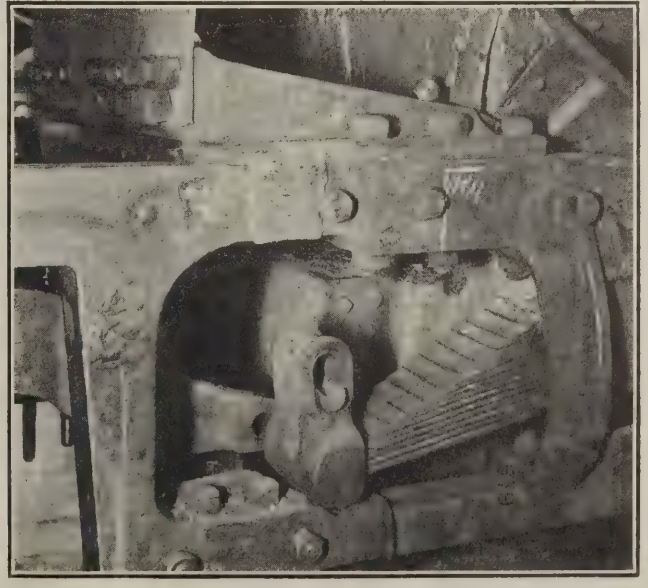


Fig. 9. Same as Above After Filling with Metallic Electrodes.

the labor being paid at 30 cents per hour and the current at 2 cents per kilowatt hour. All of these were done by men of ordinary ability after being instructed by the manufacturer's demonstrators.

Steel casting, shrinkage crack 6" long by 1" deep	8 min.	$00.04
Steel casting, riser 4" by 4" cut off	4 min.	.05
Forged steel locomotive frame, broken in 2 places	20 hrs.	18.28
Crack in back sheet of locomotive boiler, 12" long	9 hrs.	5.47
Building up worn driving wheel instead of turning down	2 hrs.	.72
Welding 67 cracks in old fire box (saving over $1,000)	2 weeks.	52.60
Cast steel tender frame, broken in 3 places	27 hrs.	19.00
Steel shaft, 2" diameter, welded ready for re-turning	1 hr.	.60
Broken railway type motor case, cast steel	3 hrs.	1.95
Enlarged holes in brake levers, steel bars	4 min.	.05
Building up 2" armature shafts, worn in journals	3 hrs.	1.80
Air brake piston rods, broken	30 min.	.35
Leaking axle boxes, cracks, welded in place	15 min.	.15

The foregoing covers but a few of the many kinds of jobs which continually arise in locomotive and car shops, but will give a fair general idea of what can be done. The following list shows what was done in one of the largest street railway shops in the far West with a graphite arc outfit during the past year.

	Cost	New	Saving
Armature shaft repaired in place	$1.70	$ 4.72	$ 3.02
Armature shaft repaired in place, large	1.97	15.13	13.16
Railway motor axle cap, large	.22	3.51	3.29
Railway motor armature bearing cap	.27	6.07	5.80
Railway motor gear case, top half	.48	7.30	6.82
Truck side frame, Brill 27-G	.72	44.40	43.68
Brake-heads, building up worn sockets	.06	1.15	1.09
Grip crotches	.72	10.00	9.28
Truck side frame, Peckham 14-B	.90	46.98	46.08
Motor frame, GE-90 railway type	2.88	16.80	13.92

The above mentioned street railway company reports that during the previous nine months they have repaired about 1,200 items which, if replaced by new items, would have cost nearly $11,000 and had also the benefit of the large amount of time saved by doing the work quickly and keeping their rolling stock in service a larger portion of the time. This is very important when considering equipment.

The following figures have been compiled in various steam railroad shops and show the comparative savings which can be effected by using the electric arc system for making repairs. The comparisons here are made between the electric system and the old methods, whatever they may be.

	Cost	Old	Saving
Engine main frames, both broken	$11.80	$ 56.20	$ 44.40
Driving wheel built up 3/16" on tread	.72	8.00	7.28
General repairs on fire box side sheets	66.51	342.62	276.11
Filling in worn knuckle joint bush. hole	.75	7.50	6.75
Locomotive cylinder casting, 7 cracks	22.35	367.15	344.50
Broken mud ring on locomotive boiler	32.07	118.06	85.99

In steel car shops this system is being used for forming frames, putting on the siding and roofs, attaching mouldings and all other parts of the trim, making up complicated sections of piping, truck bolsters and transoms and the numerous other operations formerly done with rivets or solder. In boiler shops this can be used for making all seams, attaching heads, repairing cracks, heating rivets and staybolt heads, cutting large or small holes in sheets of any thickness, etc. In forge shops they are used for cutting heavy bars as well as joining them, and the operations are both better and quicker than by the older methods and in foundries for saving defective castings by filling in or building on, for cutting off risers and heavy fins, etc.

The process of using the electric arc for either cutting out or filling in is comparatively simple and quickly learned. Of course, skill comes with practice, the same as with anything else, any man of ordinary ability and good judgment being competent to handle a good outfit. When a job is to be done the work is usually taken to the welding department, the positive lead attached to it by any suitable means, the current adjusted to suit the job and the electrode holder handled by the workman. By simply touching the electrode to the work the automatic controlling switches operate and as soon as the arc is drawn the process proceeds until completed. If the arc should be ruptured for any reason, such as being drawn out too long or by the failure of the line voltage, it is easily re-established by simply touching the work and drawing away again as before, and so on as long as the line is alive or the job requires.

The accompanying illustrations, Figs. 3 to 13, inclusive, show several jobs done in steam railroad shops with the C. & C. apparatus. Figs. 3, 4 and 5 show some difficult repairs on the inside of locomotive boilers which saved the cost of entirely new plates in most cases, and were done in less than a day

Fig. 10. Thin Metal Pieces Welded with Metallic Electrodes.

each. Figs. 6 and 7 show a locomotive side frame broken through the lower member and joined by arc welding. Figs. 8 and 9 show the method of welding a broken upper frame of a locomotive. The frame is first melted out with the carbon arc at the fracture sufficiently to give access to the work with the electrode, and then filled in to join the pieces. Fig. 10 shows several of the common thin metal parts that require joining to make up various articles such as heater coils, pipe branches, etc. Figs. 11 and 12 show a cast iron steady rest for a lathe before and after repairing with the metallic electrode, and Fig. 13 shows the housing of a large radial drill after welding the hub.

Broadly speaking, the same kind of material is used for filling as is in the body worked upon. It is necessary, however, to secure material with a slight excess of those elements which vaporize at the high temperatures used, unless it is desired to have the joint harder or softer than the piece. By varying the carbon content this can be regulated within very close limits. Alloys of steel, such as manganese-steel, nickel-steel, silicon-steel, etc., have all been used successfully, and the C. & C. Co. have recently developed a successful method of welding copper, aluminum, bronzes, etc., with the metallic process. They have also been very successful with cast iron, one of the hardest materials to weld successfully.

The cost of welding with the electric arc is lower

than by any other method, usually being about one-fourth that of the gas systems, and the time required is only about one-half that with gas. This applies to the oxy-acetylene, oxy-hydro and blau-gas processes, and is due to the higher cost of the gases as well as

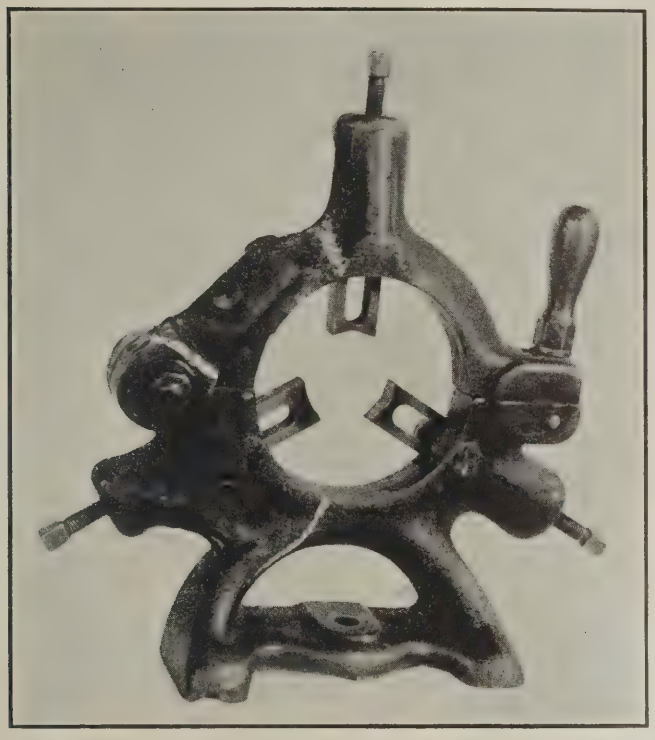


Fig. 11. Broken Cast Iron Steady Rest for Lathe.

to their lower temperatures, the latter being the cause of the greater time required to perform a given piece of work. With the electric arc it is not necessary to keep a large portion of the work heated to prevent chilling of the filling material, because the work forms the positive terminal and enough volume of heat is

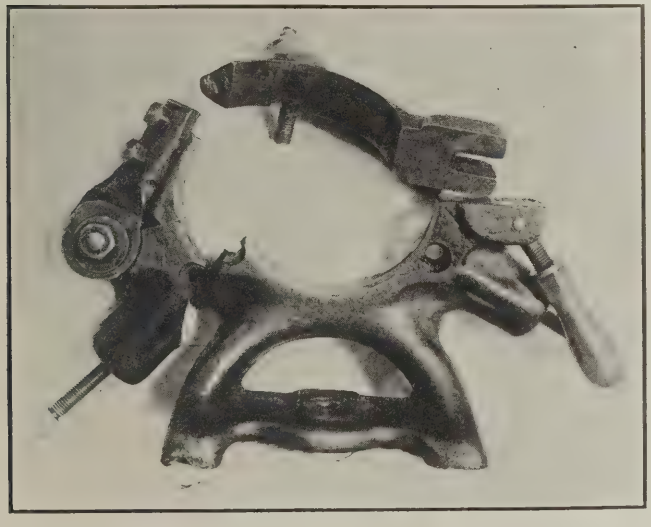


Fig. 12. The Above Welded with Metallic Electrode.

available at the point worked upon to insure perfect union. This also reduces the liability to buckle or give away after cooling because there are no very great stresses set up in the material surrounding the welded space.

When filling in, if the joint is hammered occasionally the increased strength obtained over an un-hammered joint will be worth the extra time taken. With thin materials it is possible to get joints stronger than the original piece, but with heavier sections the average strength is from 90 to 95 per cent unless the joint is carefully hammered or enough excess metal deposited to increase the cross section.

In conclusion, it may be stated that there is no class of work which offers such benefits to be gained by the use of the electric arc welding system as railroad shops, either steam or electric, and the next few years will undoubtedly see a large number of them so equipped. Their simplicity, ease of operation, flexibility, economy, rapidity and high efficiency should certainly appeal to every master mechanic

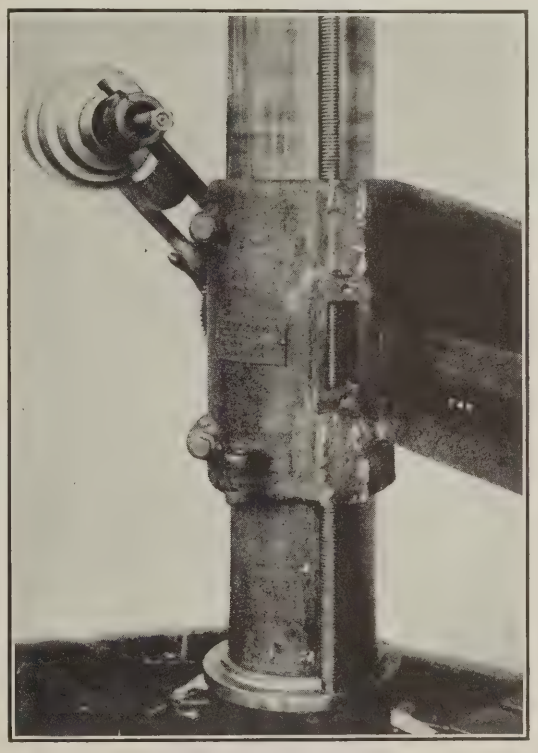


Fig. 13. Cast Iron Radial Drill After Being Welded.

and superintendent of motive power, and there is no doubt that they will as soon as they are thoroughly understood.

NEW CATALOG OF GEORGE CUTTER COMPANY.

The George Cutter Company of South Bend, Indiana, has just issued a new catalog of electric lighting and wiring devices. This is a 130-page booklet showing all the various wiring and lighting equipment manufactured by this company, including street-hoods, arc fixtures, mast arms, pulleys, insulators, pole line material, mazda arcs, idealite fixtures, knife switches, terminals and connectors, receptacles, panel boards, switch boards, and other wiring specialties. The booklet will be sent to any of our readers upon post card request to the company.

NEW EYE COMFORT BULLETIN.

The National X-Ray Reflector Company of Chicago has just issued the second of a series of booklets on the various applications of indirect lighting. It deals with indirect lighting in office buildings and will be sent upon post card request to any of our readers.

School of Electricity

Lesson No. 1

A Course of Training Prepared by the Pennsylvania Railroad for Its Employes

EDITOR'S NOTE:
Through the courtesy of the officials of the Pennsylvania Railroad, we have been given special permission to publish this entire course in the *Railway Electrical Engineer*, so this valuable training in electricity, which was originally intended only for P. R. R. men, now becomes available to all railroad men. A complete lesson of this course will be published in each issue.

DIRECT CURRENT.

It is desired to give special attention in these papers to the methods of producing electricity, the apparatus used for this purpose, methods of conveying it to the point where it will be used, the apparatus in which it will be used, and the principles governing the behavior of the apparatus under the different conditions.

Electricity is a form of energy and may be readily transformed into other kinds of energy. It may be transmitted between distant points over suitable connections, or, as is now being done to a limited extent, by wireless. These methods make it the only successful carrier of energy over long distances. The behavior. This is more than we can say of electricity—we do not know what it is, but we know how it is produced for various purposes, how it behaves under certain conditions, as its laws are very well understood, and can also see the effects produced and appreciate them. For this reason, it should be considered in the same sense as light, heat or chemical action, studying the causes and effects.

The *conductors* and apparatus beyond the switch are said to

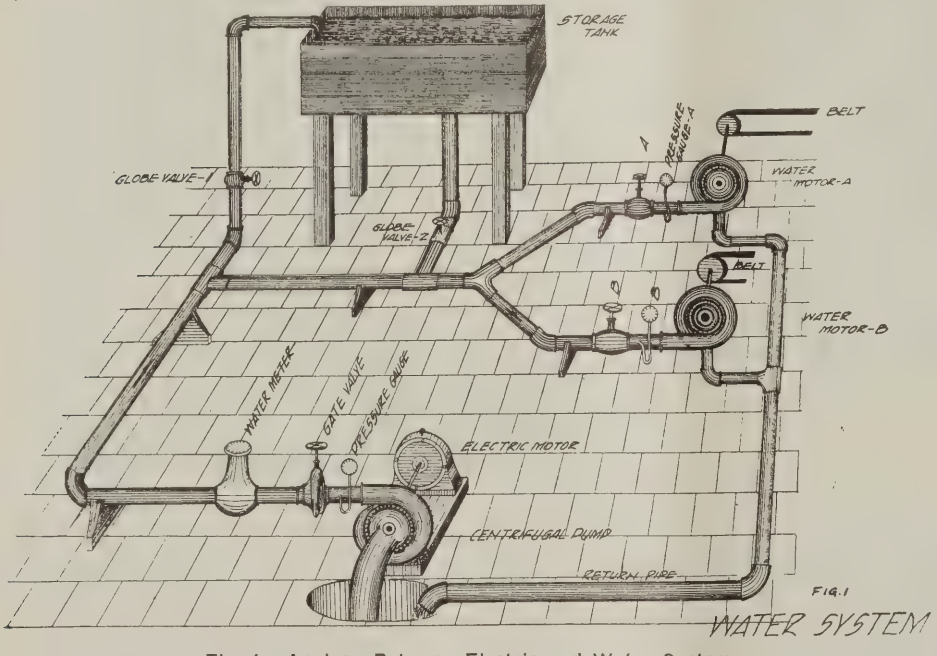


Fig. 1. Analogy Between Electric and Water Systems.

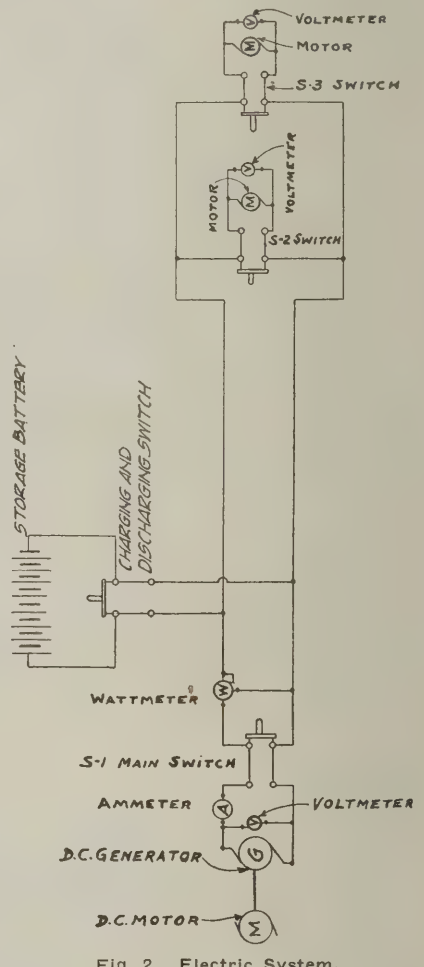


Fig. 2. Electric System.

changing of electrical energy to other forms is electrical work, and the rate of this change, is electrical power.

Before proceeding further, the student should be warned against forming an erroneous idea of electricity. From the fact that a comparison is made with the water system, it might be assumed that it possessed certain dimensions, such as weight, density, etc., similar to water. Such is not the case and ideas formed on this basis will be misleading.

Electricity, according to our best authorities, is not a material substance. No matter how much power is being transmitted over a conductor, how much charge there may be in a condenser or in a storage battery, they will weigh no more than when electrically dead or disconnected and discharged. Its exact nature is unknown. The terms "current," "volume," "direction," "density" "polarity," etc., are simply arbitrary terms adopted to designate the different manifestations of its force.

To get an idea of the electric circuit it is many times compared with a water system consisting of a pressure pump, piping of various sizes, storage tank, valves, meters, gauges, etc., with which all are familiar. This differs from the electric circuit in that the water is something tangible which we can appreciate with several of our senses, as we can see it, feel it, hear it (if it is running), taste it, and sometimes smell it. We know definitely what water is composed of, how it behaves under certain conditions and the laws of nature which govern its be *dead* when they are cut off by the opened switch and *alive* when the current is on.

The generator, if a dynamo, corresponds to the pump in the water system, as each develops a pressure in the circuit, which is responsible for a flow through the system. Each must be driven by some power such as a steam engine, turbine, water wheel or motor. The rating of a pump is usually in terms such as gallons per hour at a given number of revolutions per minute and raising the water a given number of feet, or, what is the same thing, at a given number of pounds pressure per square inch. A generator is rated in horsepower or kilowatts when running at a given speed and developing a given electrical pressure, for example, 50 horsepower, 1,000 revolutions per minute, 115 volts, 325 amperes.

The *voltmeter* in the electrical circuit registers the electrical pressure developed by the generator and corresponds to the *pressure gauge* of the water system.

Volt.—The unit of electrical pressure is the *volt,* and will be constantly referred to in all electrical papers or discussions. It is a term which corresponds to the water pressure, which is in pounds per square inch.

The ordinary lighting circuit is 110 volts, while the trolley circuits are usually 500 to 600 volts, being considered dangerous.

Other terms meaning the same as electrical pressure are *tension, voltage,* E.M.F., which is an abbreviation of *electromotive force, potential difference.* For example, it is common

to speak of a high tension line, the voltage of a lighting circuit or motor, the E.M.F. of a battery, etc.

The International Volt is that E.M.F. that when steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampere, and which is practically $\frac{1000}{1434}$ of the E.M.F. of a standard Clark cell at a temperature of 15° C. The Clark cell is a small cell used for standardization purposes only, as it retains a steady E.M.F. for several years if no current is drawn from it. The elements are mercury for positive electrode and amalgamated zinc for the negative electrode and the electrolyte is a solution of zinc sulphate and mercurous sulphate. It gives an E.M.F. of 1.434 volts at 15° C.

The gate valve is used to shut off the flow of water from the pump to the system and thus acts the same as the knife switch of the electrical system. It is different in this respect—with the valve the flow can be gradually reduced from the full capacity of the piping to nothing, while with the switch there are no intermediate quantities. The electric circuit is either closed through it or it is opened entirely by it.

Comparison of Electric with Water System.

Electric System.		Water System.
M—Motor	corresponds with	Motor driving pump.
G—Generator	"	" Centrifugal pump.
V—Voltmeter	"	" Pressure gauge.
S-1—Main Switch	"	" Gate valve.
W—Wattmeter	"	" Water meter.
Storage Battery	"	" Storage tank.
Charging and Discharging Switch	"	" Globe valves 1 and 2.
Wiring	"	" Pipe system.
S-2—Switch	"	" Globe valve A.
M & V—Motor and Voltmeter controlled by S-2	"	" Water Motor A and Pressure Gauge A.
S-3—Switch	"	" Globe valve B.
M & V—Controlled by S-3.	"	" Water Motor B and Pressure Gauge B.

Ampere.—The water meter measures directly the number of gallons which have passed through it, and is independent of the pressure per square inch, but it does not show the rate of flow at any given instant. The ammeter measures in *amperes* the rate of flow of the electric current at any instant.

The international ampere is that constant current which, when passing through a certain solution of nitrate of silver in water, will cause a deposit of silver at the rate of 0.001118 grains per second.

Watt.—The product of volts and amperes is known as *watts*. The *watt* is the unit of power, and is obtained when the electromotive force or pressure of a circuit is one volt and the rate of flow is one ampere. The term "kilowatt" means 1,000 watts, and is practically 1⅓ horsepower, or to be exact, 746 watts equals 1 horsepower. The power transmitted by a circuit, and the rating of power apparatus, are usually expressed in watts.

Horsepower.—The value of the unit "horsepower" is understood to mean 33,000 foot pounds per minute. That is, a power capable of raising 33,000 pounds one foot in one minute against the force of gravitation. This was originally established by James Watt, the inventor of the steam engine, to give a rating to his engine. It was found by him to be about equivalent to the power of a strong London draught horse.

If the current was measured in a lighting circuit of 110 volts, supplying eight lamps of 40 watts each, it should be found to be approximately 2.9 amperes. This is found as follows: Each of the lamps consumes 40 watts, then the total power is 8×40, or 320 watts. These are on the 110-volt circuit, and, as stated above, watts equals volts, times amperes, then the number of amperes would be 320 divided by 110 or 2.9.

RESISTANCE.

All conductors offer more or less resistance to the flow of current through them. In circuits employing alternating or pulsating current, other factors enter which will be considered later. The resistance corresponds closely to the friction offered to moving bodies. Friction is manifested by the generation of heat which, of course, requires a certain amount of energy to produce and which is usually a total loss. The unit of resistance in the electrical circuit is called the *ohm*, and is that resistance which is offered to the flow of one ampere of current if one volt pressure is required to produce and maintain that current.

The international ohm is that resistance offered to an unvarying electric current by a column of mercury 106.3 cm. long, at a temperature of melting ice, 0° C., of unvarying cross section, and weighing 14.4521 grams.

The flow of current through conductors offering a certain resistance generates heat, which is lost or dissipated in the atmosphere. This is the big loss in power transmission over long distances, but it can be very accurately calculated if the length, material, size and temperature of the conductor are known. Unlike friction, this is independent of the shape of the conductor. It can be determined by measuring the voltage required to establish and maintain a given current which should also be measured by proper instruments.

The mile-ohm is a term now used frequently by some engineers in speaking of different line conductors. This means the weight of a piece of wire a mile long that has a resistance of one ohm, and is found by multiplying the weight per mile of the material by the resistance in ohms per mile. From the wire table No. 12BB iron wire weighs 170 pounds per mile and has a resistance of 34.12 ohms. Then $170 \times 34.12 = 5800$, the number of pounds per mile-ohm of this material and gauge. It is evident that the poorer the conductor the higher will be this weight, as the cross section will necessarily be larger to secure this low resistance. Some of the common conductors are as follows:

Soft copper .....859 pounds per mile-ohm.
Hard copper .....880 pounds per mile-ohm.
Aluminum .....384 pounds per mile-ohm.
Iron .....4700-6000 pounds per mile-ohm.

Ohm's Law should be memorized as it is continually used in connection with electrical work. It is as follows: "The value of current, expressed in amperes, is invariably equal to the electro-motive force expressed in volts, divided by the resistance expressed in ohms." This may be more simply expressed by the equation:

$$\text{Current} = \frac{\text{Electro-motive Force}}{\text{Resistance}}$$

or using the units of each quantity

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

These are usually abbreviated, using "I," or as was earlier used, "C" for amperes; "E" for volts, and "R" for ohms. Then the above becomes:

$$I = \frac{E}{R} \qquad \text{eq. (1)}$$

From this equation: $E = R\,I$ eq. (2)

and: $R = \frac{E}{I}$ eq. (3)

so that if any two are known, the other can be determined.

Wire tables show the resistance per thousand feet and per mile of annealed and hard-drawn copper, BB and EBB galvanized iron wire and galvanized steel wire, so that from the length of wire that is to be used on a given circuit, the proper voltage can be determined to obtain a given current. In deciding upon a size of wire for a given service consideration should also be given to the safe current carrying capacity of the wires, as shown in another table. These are limited by the heating effects of the currents.

To illustrate the application of the above formulas, take a familiar example. Ten gravity cells are connected in series, giving say 10 volts on a telegraph circuit composed of 3,250 ft. of No. 10 B. & S. copper wire through two 50-ohm sounders and two keys. At a temperature of 68 degrees F. the wire has a resistance (from the wire table) of .9972 ohms per M ft. What would be the value of the current in amperes, assuming that the internal resistance is two ohms per cell?

The total resistance, disregarding the resistance of the keys which is negligible, is the sum of the other resistances as they are all in series. This is $3.25 \times .9972 + 50 + 50 + 20 = 123.24$ ohms. Then from substitution in eq. 1

$$I = \frac{10}{123.24} = .081 \text{ amperes.}$$

In like manner, either of the other two quantities may be found if any two are known.

Example: The internal resistance of a battery is 2 ohms, the external resistance of the circuit is 12 ohms, the current is 1.5 amperes. What is the voltage of the battery?

Solution: The total resistance of the circuit is $2 + 12 = 14$ ohms. From equation 2, the voltage is equal to the resistance multiplied by the current or $E = RI$. In this problem $R = 14$ and $I = 1.5$. Then $E = 14 \times 1.5 = 21 =$ number of volts.

Example: What is the total resistance of the circuit through which there is a current of 0.5 ampere when the E.M.F. of a battery is found to be 18 volts?

Solution: From equation 3, the resistance equals the number of volts divided by the number of amperes current, or $R = \frac{E}{I}$. By substituting the values from this equation $E = 18$ and $I = 0.5$. Then

$$R = \frac{18}{0.5} = 36 = \text{number ohms resistance.}$$

Watts = volts times amperes.

$$W = E \times I \qquad \text{eq. (4)}$$

From equation 4, the following equations may be obtained:

$$E = \frac{W}{I} \qquad \text{eq. (5)}$$

$$I = \frac{W}{E} \qquad \text{eq. (6)}$$

Since in equation (2) $E = RI$, we can substitute this value in equation 4 and obtain:

$$W = I^2R \qquad \text{eq. (7)}$$

The quantity I^2R in equation 7 is sometimes called the "copper loss" in a line, as it is that which is consumed by the conductors and is dissipated as heat. In the regular transmission line, this is spread over the entire length of the line and the temperature rise of the wires, if of the proper size, is so small that it could hardly be detected from the heat emitted. With the resistance coils of trolley car heating devices, electric soldering irons, glue pots, and many household devices, such as toasters, electric irons and heaters, this temperature rise is very appreciable.

From equation 7, the following equations may be obtained:

$$R = \frac{W}{I^2} \qquad \text{eq. (8)}$$

$$I = \sqrt{\frac{W}{R}} \qquad \text{eq. (9)}$$

By combining equations 1 and 4, that is, substituting the value of $I = \frac{E}{R}$ for I in equation 4 this may be written:

$$W = \frac{E^2}{R} \qquad \text{eq. 10)}$$

or

$$R = \frac{E^2}{W} \qquad \text{eq. (11)}$$

and

$$E = \sqrt{WR} \qquad \text{eq. (12)}$$

Example (a): How many watts of power are being furnished to run a motor if an ammeter (current measuring instrument) shows that 40 amperes are flowing and the voltmeter (pressure measuring instrument) indicates 108 volts?

Solution: From equation 4, watts are equal to the product of the number of volts and amperes, that is $W = EI$. In this problem $E = 108$ and $I = 40$, then $W = 108 \times 40 = 4320 =$ the number of watts.

Example (b): When a wattmeter (power measuring instrument), connected in a circuit registers 50 watts and the ammeter shows 2 amperes, what is the voltage?

Solution: From equation 5, the pressure in volts is found by dividing the number of watts by the number of amperes, that is $E = \frac{I}{W}$.

From the quantities in the problem $W = 50$ and $I = 2$, then by substituting these quantities in the equation

$$E = \frac{50}{2} = 25 = \text{voltage of circuit.}$$

Example (c): If it was required to know the current carrying capacity that a wire must have to transmit 50 watts at 25 volts, it could be found by applying formula No. 6.

Solution: Watts = 50 and volts = 25, then by substituting these values in the equation $I = \frac{W}{E}$ the quantities above, this becomes

$$I = \frac{50}{25} = 2 = \text{the current in amperes.}$$

Example (d): A certain transmission line is carrying 60 amperes and the total line resistance is 10 ohms. What is the total line loss in kilowatts?

Solution: From equation 7, the watts are equal to the product of the current squared and the resistance, that is $W = I_2R$.

In this problem $I = 60$ and $R = 10$, then by substituting these values in the equation it would read as follows:

$W = 60^2 \times 10 = 60 \times 60 \times 10 = 36{,}000$ watts; 36,000 watts = 36 kilowatts.

Example (e): If the watts and current were the same as in example (b) above, that is W=50 and I=2, what is the resistance of the circuit?

Solution: From equation 8, the resistance is equal to the number of watts divided by the square of the current, or $R = \frac{W}{I^2}$. In this example $W = 50$, $I = 2$, and by substituting in the equation $R = \frac{50}{2^2} = 50 \div 4 = 12.5 =$ number of ohms resistance in the circuit.

Example (f): What current must be provided for if it is desired to deliver 40 watts through a resistance of 8 ohms?

Solution: From equation 9, the current is equal to the square root of the number of watts divided by the number of ohms, or this may be written $I = \sqrt{\frac{W}{R}}$. In the problem $W = 40$ and $R = 8$.

Then by substituting in the equation the quantity $I = \sqrt{\frac{40}{8}} = \sqrt{5} = 2.23 =$ the number of amperes in the circuit.

Example (g): What is the total amount of power wasted in a circuit if the voltage drop is 60 and the total line resistance is 10 ohms?

Solution: From equation 10 the total watts is equal to the square of voltage divided by the resistance, or $W = \frac{E_2}{R}$. In this problem $E = 60$ and $R = 10$. By substituting these values in equation 10, $W = \frac{60_2}{10} = 60 \times 60 \div 10 = 360. =$ number of watts lost.

Example (h): If the voltage of a circuit was known to be 120 and the total power supplied was 2 kilowatts (K. W.), what is the total resistance of the circuit?

Solution: From equation 11, the total resistance is equal to the square of the voltage divided by the total watts or $R = \frac{E_2}{W}$. By substituting the values of $E = 120$ and $W = 2{,}000$ in the above equation the problem would be solved as follows:

$$R = \frac{120_2}{2{,}000} = \frac{14{,}400}{2{,}000} = \frac{144}{20} = 7.2 = \text{number of ohms resistance in circuit.}$$

Example: What will it cost to use an electric soldering iron three hours when the power costs 10 cents per kilowatt hour, if the iron is working on 110 volts and requires one ampere of current?

Solution: The total power consumed in watt-hours would be the product of volts, amperes and hours, or $110 \times 1 \times 3 = 330$ watt-hours. From page 33, one kilowatt is equal to 1,000 watts. Then:

$$\frac{330}{1{,}000} \times \$0.10 = \$.033. \quad \text{Answer.}$$

The resistance of the winding in this iron was $\frac{110}{1} = 110$ ohms. The wire had to be of such a size that it would safely carry one ampere of current and not heat up hotter than is necessary for soldering.

In the design of electrical apparatus, it should always be borne in mind that a certain amount of energy is lost as heat, depending upon the current and resistance, and that provision must be made to radiate this or else excessively high temperatures are sure to be reached. The hotter the conductor, if copper, the higher the resistance, and this keeps on increasing until the temperature is sufficiently high to ruin the insulation of some of the parts, which then allows them to short circuit. For this reason the temperature rise in the parts of a motor or generator is one of the things specified and which should be closely watched in tests of such equipment, and it is this factor which determines the maximum amount of current to be carried in a given size of wire on page 15.

As with the water system, the electric current or charge has a tendency to flow from a point of high potential or head to one of lower potential head or pressure.

ELECTRICAL CONDUCTORS.

The electric circuit, which is the external path from one terminal of the generator through the conductors and apparatus back to the other, is considered open or broken, if there is any break in the connections, which would prevent the current from flowing through the circuit. If there is a connection between the two terminals which allows the current to pass through between them without going through any of the apparatus except just the conductors, it is considered a short circuit. Unless protected by fuses or circuit breaker, a short circuit is very liable to injure the generator, the insulation of the conductors, and possibly set fire to the adjoining fittings if they are inflammable. The heat increases very rapidly with increases of current, as from equation 7 it increases as the square of the current. To illustrate the meaning of this statement, let a certain conductor be carrying a current of say 5 amperes at a normal temperature of 60 degrees F. Now, if by some means these conductors become short circuited and the current increases to 20 amperes, what would be the result, if the fuses protecting the circuit did not blow out and open the circuit? The energy to be dissipated by radiation by the two currents is in the proportion of 5^2 to 20^2, or 25 to 400, from eq. 7. This means that there is sixteen times as much energy spent by the current increased to four times the original current as by the original. The temperature which would be reached by this would depend upon the surrounding temperature, whether the conductor was bare or insulated, whether or not there was a current of air passing over the conductor, and whether the wire, if bare, was bright or blackened.

This temperature rise is the determining factor in limiting the current allowable for a given size of wire as shown in Table No. 1.

TABLE No. 1.—ALLOWABLE CURRENTS IN INSULATED WIRE.

B. & S. Gauge.	Circular Mills.	Rubber Insulation Amperes.	Other Insulation Amperes.
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
0000	211,600	210	312

The lower limit is specified for rubber covered wires to prevent gradual deterioration of the high insulation by the heat of the wire, but not from fear of igniting the insulation. The question of voltage drop is not considered in the above table.

The carrying capacities of Nos. 16 and 18 B. & S. are given, but *no smaller than No. 14 is to be used, except in fixtures and flexible cords for portable lamps,* to comply with the rules of the National Board of Fire Underwriters.

This table has special reference to wiring for lighting and power circuits. For bell, annunciator, telephone and telegraph wiring, smaller sizes, as Nos. 19 and 22 B. & S. are sometimes used. These must not be run in conduit with the power wires though, as it would be dangerous, and is forbidden by the rules of the National Board of Fire Underwriters governing all electrical wiring and installations.

The apparatus in a circuit is said to be connected in series when it is so arranged that all the current passes through each piece of apparatus in the circuit, that is, connected one after the other. The total resistance of a series circuit is the sum of all the resistances in the circuit.

In the circuit shown in Fig. 3 let r_1, r_2, r_3, r_4 and r_5 (these are read "small r sub one," "small r sub two," etc.) be the resistance in ohms of the electrical conductors and each equal to one ohm, R_1, R_2, R_3, and R_4 other resistances and each equal to two ohms. The total resistance of the circuit is the sum of

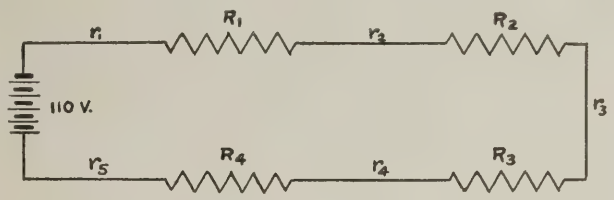


Fig. 3. Diagram of Series Circuit.

these separate resistances or $5 + 8 = 13$ ohms. If the voltage of the battery is 110, then by Ohms law, eq. 1, the current flowing is $110 \div 13 = 8.46$ amperes. The current is the same in all parts of the circuit.

The value of a conductor to carry current is inversely proportional to the resistance of the conductor. That is, if one conductor has a resistance of 2 ohms and another 4 ohms, then their conducting values would be in proportion ½ to ¼, or the one with 2 ohms resistance would be twice as good a conductor as the one having 4 ohms.

The quantity 1 divided by a number is the reciprocal of that number, thus ½ is the reciprocal of 2 mentioned above, and is twice as good as ¼, which is the reciprocal of 4.

Conductance or conductivity is the reciprocal of resistance in ohms, and is convenient to work with in determining the current values in the different branches of a divided circuit. Its unit is called the "mho," which is ohm spelled backward.

Example: Two incandescent lamps are connected in multiple or parallel across a 110-volt D. C. circuit, one being a tungsten having a resistance of 121.2 ohms and the other a carbon having a resistance of 242.4 ohms. What is the total current flowing through these lamps?

Solution: The conductivity of one branch is $\frac{1}{121.2}$ ohms and of the other $\frac{1}{242.4}$ ohms. Then the total conductivity of the Circuit will be $\frac{1}{121.2} + \frac{1}{242.4}$ or $\frac{3}{242.4}$ ohms. Their combined resistance is then $\frac{242.4}{3}$ or 80.8 ohms and the total current would be $\frac{110}{80.8}$, or 1.36 amperes.

The resistance of two conductors of the same material is inversely as their area of cross section; that is, a conductor has

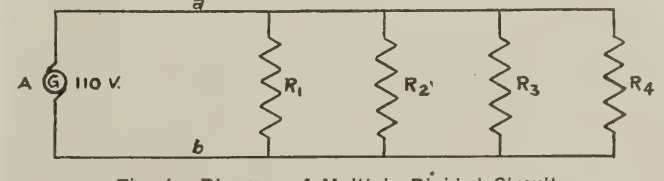


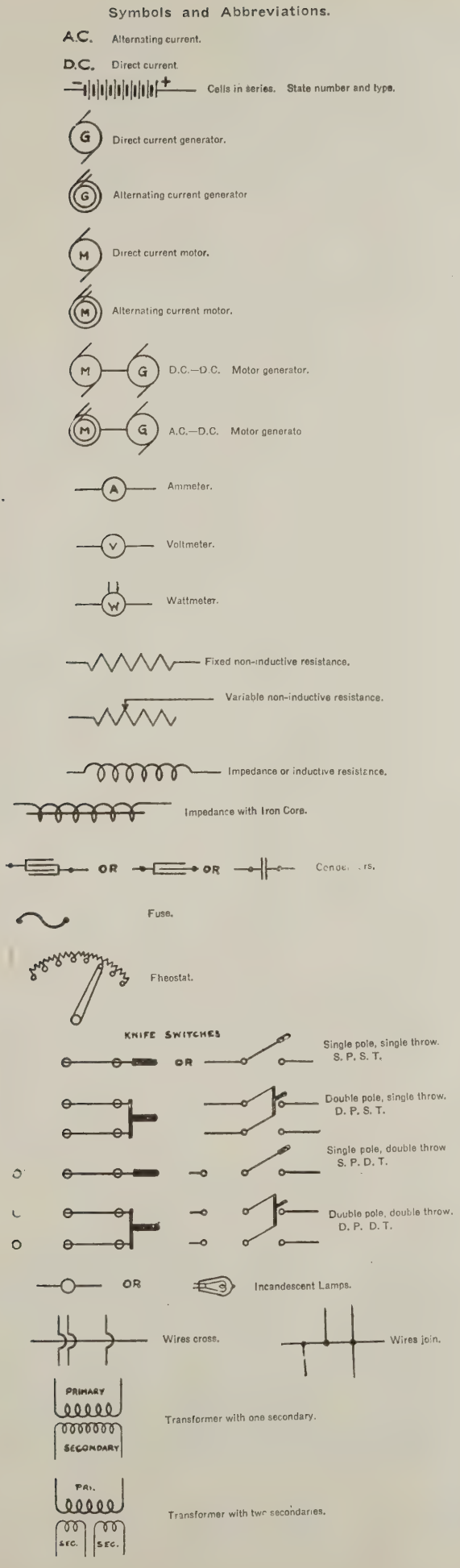
Fig. 4. Diagram of Multiple Divided Circuit.

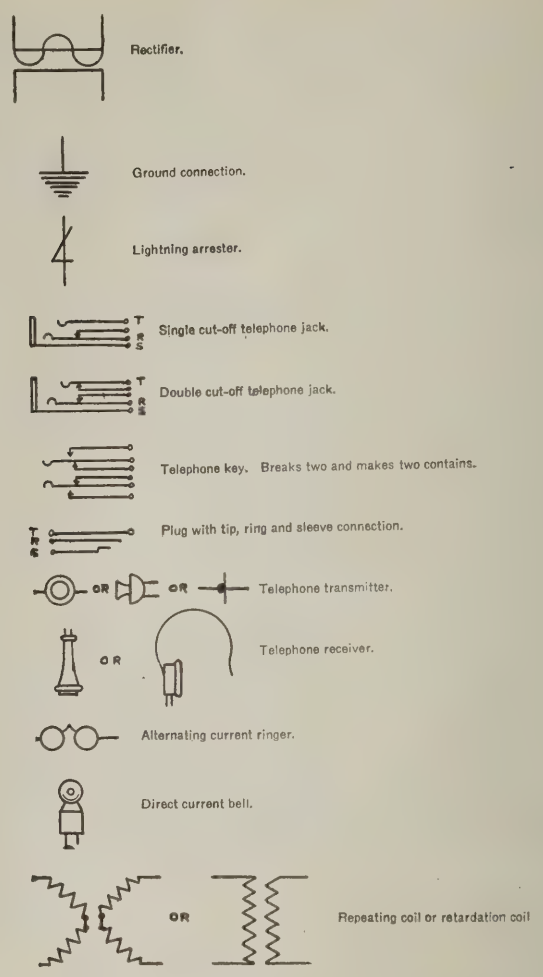
twice as much resistance for given length as one of the same material and same length, but twice as large cross section.

A circuit is said to be connected in multiple, parallel, shunt or divided circuit if it is so arranged that a part of the current passes through each of two or more branches. Each branch taken separately is called a shunt.

In Fig. 4 let "A" be a direct current generator 110 volts and R_1, R_2, R_3, and R_4 resistances of 5 ohms each. The resistance of the feeders "a" and "b" is so small that it may be disregarded; then the total current in the circuit is obtained after first determining the resistance of the circuit. This is the reciprocal of the sum of the reciprocals of the individual resistances forming the divided circuit, or in multiple.

Thus: $$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \dots} \quad \text{eq (13)}$$





The quantities R_1, R_2, R_3 and R_4 represent the resistances in ohms of the various branches of the divided circuit.

The quantity + . . . is read "plus and so on," meaning that if there were more than four branches in the divided circuit, they would be treated the same by continuing the process of adding the reciprocals or conductivities of the individual branches.

By substituting in equation 13 the values of the resistance in the different branches, we obtain,

$$R = \frac{1}{\frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{5}} = \frac{1}{\frac{4}{5}} = 1\frac{1}{4} = \text{number of ohms.}$$

Then by substituting this value of R in equation 1, which is $I = \frac{E}{R}$, we have $I = \frac{110}{1.25} = 88$ amperes, total current in circuit.

Current through any of the branch circuits is found by dividing the total voltage 110 by the resistance of that branch, or $110 \div 5 = 22$, the number of amperes. This is seen to be correct, as the four resistances are equal and the total current is 88 amperes.

In some arc light, telephone and nearly all Morse telegraph systems the series circuit is employed. With this, the whole circuit is interrupted if there is a single connection broken. The method of breaking the telegraph circuit in order to have a part of a message repeated is accomplished by merely opening the circuit at any of the keys which are in series on the Morse circuit. This break is detected by the sender, as his relay or sounder fails to respond to his signals.

With the multiple or bridging connection, only that part of the circuit is thrown out of service on which the break occurs. Both methods of connection are especially adapted for certain classes of service. These circuits will be taken up further in the papers on telephone, telegraph and power equipment.

There are several symbols that are frequently used on drawings of electric circuits and with which it is well to become familiar. They are the same as used by signal, electric light, power, telephone and telegraph divisions, and have been standardized by the national engineering organizations, so that if one has occasion to read or study drawings of electrical circuits of any nature some of them are very sure to be found.

THERMOMETERS.

In the different formulas, magazine articles, books on technical subjects, etc., there is frequently reference made to the different thermometer scales. The principle ones are Centigrade and Fahrenheit.

The Centigrade scale has 0° for the freezing point of water and 100° for the boiling point of water at mean atmospheric pressure at sea level, which is 14.7 pounds per square inch.

The Fahrenheit scale, which is most common, has 32° for freezing point of water and 212° for boiling point. From this it is seen that the difference between the freezing and boiling points on the Fahrenheit scale is 180°, which is equal to 100° on the Centigrade scale. This furnishes a basis for the comparison which follows:

1 Fahrenheit degree equals 5/9 degrees Centigrade.
1 Centigrade degree equals 9/5 degree Fahrenheit.
Temperature Fahrenheit equals 9/5 temperature C + 32°.
Temperature Centigrade equals 5/9 (temperature F—32°).

TABLE No. 2.—COMPARISON OF THERMOMETER SCALES.

1		2		3	
C.	F.	C.	F.	C.	F.
—40	—40	10	50	60	140
—35	—31.	15	59.	65	149.
—30	—22.	20	68.	70	158.
—25	—13.	25	77.	75	167.
—20	— 4.	30	86.	80	176.
—15	+ 5.	35	95.	85	185.
—10	14.	40	104.	90	194.
— 5	23.	45	113.	95	203.
0	32.	50	122.	100	212.
+ 5	41.	55	131.		

The freezing point of pure water is nearly constant for the ordinary air pressure upon its surface; at high pressures the freezing point is lowered at the rate of .0133° F. for each additional atmosphere (14.7 pounds per square inch) of pressure. Water under ice in the coldest winter weather cannot be colder than 0° C.

WIRE OR CONDUCTORS.

That different metals and alloys offer different resistances to the flow of current is well known. The ones with which we are most familiar are copper and iron. All of the different metals are affected by chemical impurities, mechanical treatment and by changes in the temperature to which they are subjected. It is difficult to determine the nature or extent of the impurities, except by making a careful chemical analysis of the sample in question. The mechanical treatment has reference to the methods employed in drawing the wire which fixes the structure or arrangement of particles forming it, as hard-drawn and annealed copper. These are both of the same material, but are differently treated in the process of manufacture.

Hard-drawn Wire.

The processes used in the manufacture of wire are somewhat out of the field of this paper, but it is believed that it would be desirable to have some idea regarding the methods of producing the hard-drawn copper line wire with which we are familiar.

The metal is first cast into "ingots" or "blooms" about six inches square and three or four feet long. It is then passed through a series of rolls, which change it to a long rod of small diameter, circular in cross section and three-eighths of one inch in diameter. If it is desired to produce a wire of smaller diameter, the rods are drawn through a series of dies, each reducing it by a certain amount. These dies are made of hardened steel, agate or sometimes lined with diamonds, as it is extremely important that these dies do not change by wear. For this reason the very hardest substances are necessary.

The process of pulling the wires through these dies to reduce the diameter changes greatly the structure of the metal, the rod becoming greatly compressed and hardened, which at the same time increases the tensile strength of the wire. This, however, reduces the elasticity accordingly, so that there is almost no stretch or elongation noticeable before the wire breaks when put under test. This hardening effect is very similar to the results obtained by tempering steel. The hard-drawing process increases the tensile strength to nearly double that of the annealed copper, although the resistance is increased two to four per cent. The effect of the hard-drawing process seems to be confined principally to a very thin layer or the skin on the surface of the wire, as any slight scratch, nick or cut having a tendency to destroy or cut through this skin very greatly reduces the strength of the wire. If the specimen so punished is put under test, it is very sure to break at the point where this cut or nick occurred, and the entire effect of the hard drawing, which was primarily to increase tensile strength, will be lost. This brings us to the point that it was desired to bring out, that "Hard-drawn Copper Wire must be Handled Carefully" to prevent injury to this surface skin.

The increase in tensile strength produced by the hard-drawing processes is more marked in the smaller than in the larger gauges, as the wire has been subjected to the drawing process a few more times. Thus the smaller sizes have a higher tensile strength per square inch than the larger sizes. The soft-drawn copper wire has a tensile strength of about 34,000 pounds per squart inch, while hard-drawn is 50,000 pounds for 0000 and 00; 55,000 for No. 0; 57,000 for No. 1 and 60,000 for the smaller sizes.

In this drawing process, a lubricant of tallow or soapy water is used on the wire. When the wire is received from the factory, it sometimes has a thin film of grease on the surface; this is more noticeable in cold weather. It should be carefully removed at the ends when making a splice in order to prevent the wire from slipping in the sleeve. The wire should not be

TABLE No. 3.—PROPERTIES OF COPPER WIRE.

Number B. & S. Gauge	Diameter "d" in Mils. 1 Mil = .001 Inch.	Area in Circular Mils d^2.	Area in Square inches $d^2 \times .7854$.	Weight per Unit of Length. Specific Gravity, 8.89. Pounds per 1000 Feet.	Pounds per Mile.	Feet per Pound.	Ohms per Pound Annealed.	Resistance in International Ohms at 68° F. According to Matthiessen's Standard of Resistivity. Ohms per 1000 Ft. Annealed.	Ohms per 1000 Ft. Hard-Drawn.	Ohms per Mile. Annealed.	Ohms per Mile. Hard-Drawn.	Feet per Ohm Annealed	Tensile Sgth. in Pounds. Annealed.	Tensile Sgth. in Pounds. Hard-Drawn.	Elong. % in 1 Foot. Annealed.	Elong. % in 1 Foot. Hard-Drawn.	Safe Cur. Amperes. Bright Wire Paneled.	Safe Cur. Amperes. Black Wire in Free Air.	Turns per Lin. In. Cotton Covered.	Temperature Coefficients. Temp. in Deg. C.	Temperature Coefficients. Resistance per Mil-Foot, Ohms.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
0000	460.000	211600.00	.166190	640.5	3381.4	1.561	.00007639	.04893	.050036	.25835	.26419	20440	5650	9975	45.0	5.00	146.0	346.0	1.6	0	1.00000
000	409.642	167806.43	.131794	508.0	2682.2	1.969	.0001215	.06170	.063094	.32577	.33314	16210	4475	7900	45.0	5.00	127.0	292.0	1.6	1	1.00387
00	364.796	133076.66	.104518	402.8	2126.8	2.482	.0001931	.07780	.079558	.41079	.42007	12850	3550	6230	45.0	4.00	110.0	247.0	1.8	2	1.00776
0	324.861	105534.50	.082887	319.5	1686.9	3.130	.0003071	.09811	.10033	.51802	.52973	10900	2800	4950	45.0	4.00	95.0	209.0	2.8	3	1.01166
1	289.296	83692.67	.065732	253.3	1337.2	3.947	.0004883	.1237	.12649	.65314	.66790	8083	2225	3925	42.0	4.00	83.0	177.0	3.2	4	1.01558
2	257.626	66371.31	.052128	200.9	1060.6	4.977	.0007765	.1560	.15953	.82368	.84239	6410	1750	3125	39.0	3.00	72.0	148.0	3.4	5	1.01950
3	229.422	52634.37	.041339	159.3	841.09	6.276	.001235	.1967	.20114	1.0386	1.0621	5084	1400	2450	36.0	3.00	63.0	127.0	3.9	6	1.02343
4	204.307	41741.32	.032784	126.4	667.39	7.914	.001936	.2480	.25361	1.3094	1.3392	4031	1100	1950	33.0	2.50	55.0	108.0	4.5	7	1.02738
5	181.941	33102.37	.025999	100.2	529.06	9.980	.003122	.3128	.31987	1.6516	1.6889	3197	875	1550	30.5	2.50	48.0	91.0	5.0	8	1.03134
6	162.022	26251.37	.020618	79.46	419.55	12.58	.004963	.3944	.40332	2.0825	2.1295	2535	700	1225	28.0	2.00	42.0	78.0	5.6	9	1.03531
7	144.285	20818.35	.016351	63.02	332.75	15.87	.007892	.4973	.50854	2.6258	2.6850	2011	550	975	26.0	2.00	37.0	66.0	6.2	10	1.03929
8	128.490	16509.64	.012967	49.98	263.89	20.01	.01255	.6271	.64127	3.3111	3.3859	1595	425	775	24.0	1.75	32.0	56.0	7.0	11	1.04328
9	114.434	13092.75	.010283	39.63	209.24	25.23	.01995	.7908	.80876	4.1753	4.2769	1265	325	600	21.5	1.75	28.2	48.0	7.5	12	1.04728
10	101.897	10383.02	.0081548	31.43	165.95	31.82	.03173	.9972	1.0199	5.2657	5.3848	1003	275	475	19.0	1.50	24.9	41.0	8.5	13	1.05129
11	90.743	8234.11	.0064656	24.93	131.63	40.12	.05045	1.257	1.2854	6.6369	6.7869	795.3	200	375	17.5	1.50	21.9	35.0	9.7	14	1.05532
12	80.808	6529.95	.0051287	19.77	104.39	50.59	.08022	1.586	1.6218	8.3741	8.5633	630.7	175	300	16.0	1.25	19.3	30.0	11.2	15	1.05935
13	71.962	5178.48	.0040672	15.68	82.791	63.79	.1276	1.999	2.0443	10.555	10.794	500.1	125	225	14.5	1.20	17.0	25.8	12.0	16	1.06339
14	64.084	4106.72	.0032254	14.43	76.191	80.44	.2028	2.521	2.5779	13.311	13.612	396.6	100	200	13.0	1.25	15.0	22.2	13.0	17	1.06745
15	57.069	3256.78	.0025579	9.858	52.050	101.4	.3225	3.179	3.2508	16.785	17.165	314.5	80	150	12.0	1.25	13.3	19.1	15.3	18	1.07152
16	50.821	2582.74	.0020285	7.818	41.277	127.9	.5128	4.009	4.0996	21.168	21.646	249.4	60	125	11.0	1.25	11.8	16.5	16.7	19	1.07559
17	45.257	2048.29	.0016087	6.200	32.736	161.3	.8153	5.055	5.1692	26.691	27.294	197.8	50	90	10.0	1.25	10.4	14.2	17.7	20	1.07968
18	40.303	1624.30	.0012757	4.917	25.960	203.4	1.296	6.374	6.5180	33.635	34.416	156.9	40	70	9.0	1.25	9.2	12.3	19.5	21	1.08378
19	35.890	1288.13	.0010117	3.899	20.595	256.5	2.061	8.038	8.2196	42.441	43.400	124.4	30	60	8.0	1.20	8.2	10.7	22.7	22	1.08788
20	31.961	1022.53	.0080231	3.092	16.324	323.4	3.278	10.14	10.372	53.539	54.749	98.66	25	45	7.0	1.20	7.2	9.2	27.0	23	1.09200
21	26.463	810.12	.0063626	2.452	12.946	407.8	5.212	12.78		67.479		78.24	23	39	6.0	1.00			31.0	24	1.09612
22	25.346	642.45	.0050457	1.945	10.268	514.2	8.287	16.32		85.114		62.05	21	32	5.0	1.00			34.4	25	1.10026
23	22.572	509.49	.0040015	1.542	8.142	648.4	13.18	20.32		107.29		49.21	18	26	5.0	1.00			38.2	26	1.10440
24	20.101	404.04	.0031733	1.223	6.457	817.6	20.95	25.63		135.33		39.02	16	20	5.0	1.00			42.3	27	1.10856
25	17.901	320.42	.0025166	.9699	5.121	1031	33.32	32.31		170.59		30.95	12	16	5.0	1.00			47.0	28	1.11272
26	15.940	254.10	.0019958	.7692	4.061	1300	52.97	40.75		215.16		24.54							52.0	29	1.11689
27	14.196	201.52	.0015827	.6100	3.221	1639	84.23	51.35		271.29		19.46							57.0	30	1.12107
28	12.642	159.81	.0012551	.4837	2.554	2067	133.9	64.70		242.09		15.43							63.4	40	1.16332
29	11.258	126.74	.0009953	.3836	2.025	2607	213.0	81.70		431.37		12.24							70.1	50	1.20625
30	10.025	100.51	.0007893	.3042	1.606	3287	338.6	103.0		543.84		9.707							77.1	60	1.24965
31	8.928	79.70	.0006259	.2413	1.274	4145	538.4	129.9		685.87		7.698							84.6	70	1.29327
32	7.950	63.20	.0004963	.1913	1.010	5227	856.2	163.8		864.87		6.105							92.7	80	1.33681
33	7.080	50.13	.0003936	.1517	.801	6591	1361	206.6		1090.8		4.841							101.6	90	1.37995
34	6.305	39.75	.0003122	.1203	.635	8311	2165	260.5		1375.5		3.839							112.1	100	1.42231
35	5.615	31.52	.0002475	.09543	.504	10482	3441	328.4		1734.0		3.045							119.7		
36	5.000	25.00	.0001963	.07568	.400	13217	5473	414.2		2187.0		2.414							130.6		
37	4.453	19.83	.0001557	.06001	.317	16666	8702	522.2		2757.3		1.915							140.6		
38	3.965	15.72	.0001234	.04759	.251	21015	13870	658.5		3476.8		1.519							151.0		
39	3.531	12.46	.0000978	.03774	.199	26500	22000	830.4		4384.5		1.204							163.4		
40	3.145	9.88	.0000776	.02993	.158	33416	34980	1047.0		5528.2		.955							177.6		

TABLE NO. 4.—COMPARISON OF WIRE GAUGES.

NUMBER	AMERICAN OR B & S.		B. W. G. OR STUB'S		N. B. S., B. I. S. OR E. L. S.	
	Diameters in Mils.	Areas, Circular Mils.	Diameters in Mils.	Areas, Circular Mils.	Diameters in Mils.	Areas, Circular Mils.
0000	460	211,600	454	206,116	400	160,000
000	410	168,100	425	180,625	372	138,384
00	365	133,225	380	144,400	348	121,104
0	325	105,625	340	115,600	432	104,976
1	289	83,521	300	90,000	300	90,000
2	258	66,564	284	80,656	276	76,176
3	229	52,441	259	67,081	252	63,504
4	204	41,616	238	56,644	232	53,824
5	182	33,124	220	48,400	212	44,944
6	162	26,244	203	41,209	192	36,864
7	144	20,736	180	32,400	176	30,976
8	128	16,384	165	27,225	160	25,600
9	114	12,996	148	21,904	144	20,736
10	102	10,404	134	17,956	128	16,384
11	91	8,281	120	14,400	116	13,456
12	81.	6,561	109	11,881	104	10,816
13	72	5,184	95	9,025	92	8,464
14	64	4,096	83	6,889	80	6,400
15	57	3,249	72	5,184	72	5,184
16	51	2,601	65	4,225	64	4,096
17	45	2,025	58	3,364	56	3,136
18	40	1,600	49	2,401	48	2,304
19	36	1,296	42	1,764	40	1,600
20	32	1,024	35	1,225	36	1,296
21	28.5	812.3	32	1,024	32	1,024
22	25.3	640.1	28	784	28	784

TABLE NO. 5.—DOUBLE GALVANIZED TELEGRAPH AND TELEPHONE WIRE.

NUMBER Birmingham Wire Gauge	Diameter in Inches	Weight in Pounds per Mile	Put Up in Bundles of	APPROXIMATE BREAKING STRAIN IN POUNDS			AVERAGE RESISTANCE IN OHMS AT 68 DEGREES F.		
				E B B	B B.	Steel	E B B	B. B.	Steel
4	.238	811	¼ mile	2433	2676	3000	5.98	7.15	8.32
6	.203	590	¼ "	1770	1947	2183	8.14	9.83	11.44
8	.165	390	½ "	1170	1287	1443	12.43	14.87	17.31
9	.148	314	½ "	942	1036	1162	15.44	18.47	21.62
10	.134	258	½ "	774	851	955	18.80	22.48	26.16
11	.120	206	½ "	618	680	762	23.54	28.15	32.76
12	.109	170	½ "	510	561	629	28.53	34.12	39.70
14	.083	99	½ "	297	327	366	49.00	58.58	68.18

scraped to remove this film, as the wire would doubtless be injured sufficiently to reduce the tensile strength, but it may be removed by wiping with a coarse cloth, waste or burlap.

Iron Wire.

There are three kinds of galvanized wire used for line construction, as shown in the wire tables, and which are regular commercial products. The galvanizing of the three kinds E. B. B., B. B. and Steel are all the same, but the difference is in the quality of the wire itself. "E. B. B." is an abbreviation for "Extra Best Best," and is the best conductor of the three, having the lowest resistance, but the lowest tensile strength. It is used largely by some telegraph companies and some railway companies for telegraph line construction. It has a weight of 4,700 to 5,000 pounds per mile-ohm, and is the softest of the three. "B. B." is an abbreviation for "Best Best" and is somewhat inferior to the E. B. B. as an electrical conductor, having a higher resistance, but is better mechanically, as its tensile strength is higher. The weight per mile-ohm is 5,600 to 6,000 pounds. This grade is used largely by telephone companies, especially in the rural districts.

"Steel" wire is the poorest conductor, but has the highest tensile strength. It is many times used on comparatively long spans when iron wire is used in the regular line construction, as it is much stronger. As a general rule high strength in a conductor is obtained at the expense of conductivity, that is, for the same material the higher the strength the higher the resistance. It weighs 6,500 to 7,000 pounds per mile-ohm.

The galvanizing process consists in cleaning the wire by immersing or "pickling" the wire for some time in a dilute solution of sulphuric acid (oil of vitriol) and passing the wire slowly through a bath of melted zinc, or spelter as it is sometimes called. The surface of the zinc is covered with a flux of sal-ammoniac or similar compound which helps the coating to adhere to the wire. When the wire comes from this bath the excess zinc is removed, leaving the wire covered with a continuous coating of zinc, which is comparatively free from rusting in many climates. If the iron is not properly cleaned, the flux on the surface of the melted zinc not right or metal not of the proper temperature, the coating is apt to be uneven, rough or lumpy. These imperfections should be watched for when inspecting this material.

Test for galvanizing is made by immersing the sample for one minute in a dilute solution of copper sulphate, 36 parts by weight of crystals and 100 parts by weight of water, and then wiping dry. This operation should be repeated four times before any red spots occur on the wire. The sample should be rinsed in clean water and wiped dry after each operation. The red spots are deposits of copper on the exposed iron surface after the zinc coating has been destroyed. Do not use the solution for more than one test.

Approximate weight of iron wire may be found by dividing circular mils (diameter in thousandths squared) by 72, which will give pounds per mile. Pounds per thousand feet found by dividing circular mils by 380. It is nearly seven-eighths the weight of copper wire of same diameter.

Frequent reference will be made to the different wire gauges B. & S., B. W. G., N. B. S., Stub's and A. W. G. These are abbreviations for Brown & Sharp, Birmingham Wire Gauge, New British Standard, Stub's and American Wire Gauge, respectively.

The A. W. G. is the same as B. & S.; the B. W. G. is the same as Stub's; the British Imperial Standard is the same as the New British Standard or British Legal Standard.

The B. & S. Gauge originated in this country. The sizes in this system range in diameter from No. 0000, having diameter of .460 inches, to No. 40, having a diameter of .003144 inches. This gauge is so arranged that successive numbers vary in diameter in the ratio 1.123 and the diameters double almost exactly every third increase in size. The No. 10 B. & S. has a diameter nearly one-tenth of an inch and a resistance of one ohm per thousand feet at ordinary temperature. This information is many times valuable when the size or resistance of a given copper wire is wanted, and a wire table is not at hand. For instance: No. 10 has an area of 10,381 circular mils with resistance 1 ohm per thousand feet; No. 13, 5,178 circular mils and resistance 2 ohms; No. 16, 2,582 circular mils and resistance 4 ohms; No. 7, 20,816 circular mils and resistance .5 ohms.

Circular Mil.

The word mil is an abbreviation for one-thousandth of an inch, as shown in table of prefixes. The circular mil is the area of a circle having a diameter of one-thousandth of an inch, and is used as a unit of area for circular conductors. This equals:

$$\frac{.001^2 \times 3.1416}{4} = .000,000,7854 \text{ square inches.}$$

The area of a conductor in circular mils is found by squaring the diameter of the conductor in mils. For example No. 12 B. & S. has a diameter of 80.808 mils or .080808 inches. The square of 80.808 is found by multiplying 80.808 by 80.808 which is 6529.95, as shown in the wire table.

Square Mil.

This is used as a unit of area for conductors having rectangular cross section. This equals $.001^2 = .000,001$ square inches.

The micrometer gauge shown in Fig. 5 is commonly used for measuring the thickness or diameter of various substances, including wire, when an accurate dimension is required. With this gauge it is possible to measure directly in thousandths of an inch. There are several modifications of the above, but the method of reading all of them is the same. A ratchet stop, not shown in the figure, is a small knurled thumb nut for the purpose of turning the spindle down upon the body to be measured and is to prevent undue pressure being exerted on the screw, which would cause the body to be flattened. It causes uniform pressure on all samples measured. Some types are provided with a lock nut or set screw which holds the spindle firmly in one position. This is especially convenient if several samples of the same size of materials are to be gauged.

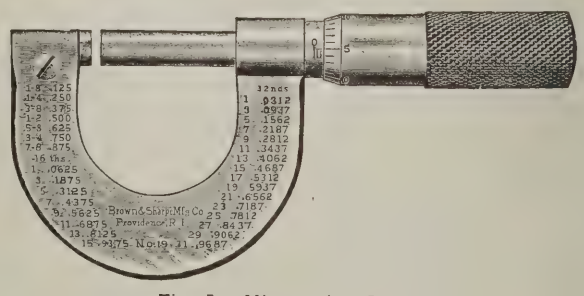


Fig. 5. Micrometer Gauge.

Construction of the Micrometer.—The U-shaped frame is of heavy hardened steel, which is very rigid. Attached to this is a hollow spindle, which is fitted with an accurately machined thread inside and a gauge with reference line outside. This gauge runs from 0 up and each of these divisions has four small divisions. The pitch of the thread inside this spindle is such that one complete turn of the thumb nut connected to the spindle inside the hollow spindle advances the movable point inside the U-shaped frame just one of these four small divisions mentioned. The movable sleeve, which is a part of the knurled thumb nut, fits closely over the hollow spindle mentioned. This is divided into 25 equal divisions and is marked 0, 5, 10, 15 and and 20. By making the thread 40 to the inch, then four complete turns would be 0.1 in., which is the meaning

Fig. 6. Wire Gauge.

of the mark 1 on the hollow spindle. One of the four divisions of this would then be ¼ of .1 or .025 in., which agrees with the number of divisions on the movable sleeve.

Method of Reading.—Suppose that after a careful adjustment of the screw the micrometer stood as shown in Fig. 5. From the above information it can be read direct as .055 in. If this had been set so that three of the first divisions on the stationary spindle were exposed and the movable sleeve stood with the seventeenth division over the reference line, then the reading would be found as follows: Each of these three divisions is .025 in. or a total of .075 in. and that portion indicated by the movable sleeve .017 in., then the total would be .075 plus .017, or .092 in. When measuring No. 9 B. & S. copper wire, which is shown in the wire table to be 114.434 mils, it would be impossible to measure closer with a micrometer than the fourth place, which would then be estimated, unless the micrometer is provided with a vernier which enables one to read directly in tenths of a mil or in ten-thousandths of an inch. The scales of the micrometer when set for No. 9 B. & S. would show the figure 1, but would not show the first of the next four divisions. The movable sleeve would stand with reference line about midway between 14 and 15. A little practice will enable one to become very proficient in using the micrometer.

Adjustment of the Micrometer.—The thumb nut should turn easily, but not be loose. When from wear of the thread it becomes too loose it can be tightened by means of a split thread at the end of the hollow spindle. When the thumb nut is turned down just tight the movable sleeve should stand with the reference line on 0. If not, this may be adjusted by means of the set screw on the side of the frame opposite the spindle and against which the spindle rests when turned down tight.

A common form of wire gauge is shown in Fig. 6. The size of wire is found by trying the different slots until one just fits tightly over the wire. The next one smaller should not go over it without undue pressure. The slot in the edge of the gauge should be used, not the hole at the base of it.

Cable No. 6.—Specific Resistance of Metallic Wires.

Material.	Resistance in Ohms at 0° C. of Wire 1 foot long .001" diameter.	Increase of Resistance for 1° C. increase of temperature at 20° C."a"
Silver, annealed	8.781	.00377
Silver, hard drawn	9.538	.0
Copper, annealed	9.529	.00388
Copper, hard drawn	9.741	.....
Gold, annealed	12.56	.00365
Gold, annealed	12.78	.....
Aluminum, annealed	17.48	.0039
Zinc, pressed	33.76	.00365
Platinum, annealed	54.35	.....
Iron, annealed	58.31	.....
Nickel, annealed	74.78	.....
Tin, pressed	79.29	.00365
Lead, pressed	115.1	.00387
Antimony, pressed	213.1	.00389
Bismuth, pressed	787.5	.00354
Mercury, pressed	565.9	.00072
German Silver	125.7	.00044
Gold-Silver (2 parts gold, 1 part Silver by weight)	65.21	.00065

The temperature coefficient "a" in the above table will make it possible to determine the resistance of a given wire at a given temperature when the resistance is known at 0° C.

$$r_t = r_0 (1 + at). \qquad \text{eq. (14).}$$

In this, r_t is the resistance in ohms of the conductor at any temperature, t_0 Centigrade, r_0 is the resistance in ohms of the conductor at 0° C. "a" is the temperature coefficient, "t" is the difference in degrees centigrade.

If it is required to know the resistance per foot of No. 14 B. & S. annealed copper wire at 20° C. which is same as 68° F., it is first necessary to determine the area of cross section of the wire. From the wire table, this is 4,107 circular mils. As the resistance of conductors of the same material is inversely proportional to the area of cross section, and as the resistance in the table is for a circular wire having a diameter of 1/1000 in. which has an area of 1 *circular mil,* it would be necessary to divide the quantity 9.529 ohms (from table) by 4107, to obtain resistance of No. 14 B. & S. at 0° C. Then by substitution in equation 14.

$$R_{20} = \frac{9.529}{4107} (1 + .00388 \times 20)$$
$$= .00232 (1 + .0776)$$
$$= .00232 (1.0776)$$
$$= .0025 \text{ ohms resistance 14 B. \& S. at 20° C. or 68° F.}$$

This will be seen to correspond very closely with the resistance given in the wire table. This formula is sufficiently accurate to determine the resistance at any ordinary temperature from any other temperature.

Prefixes commonly used in connection with electrical quantities are derived from the Greek and Latin languages as follows:

Table No. 7.—Amount of Multiplication.

Prefix.	Expressed in Words.	Expressed in Figures.
deka	ten times	10
hecto	one hundred times	100 or 10^2
kilo	one thousand times	1,000 or 10^3
mega	one million times	1,000,000 " 10^6
bega	one billion times	1,000,000,000 " 10^9
trega	one trillion times	1,000,000,000,000 " 10^{12}
quega	one quadrillion times	1,000,000,000,000,000 " 10^{15}

For example, 1 megohm is 1,000,000 ohms. This is a quantity used in specifying the resistance of the insulation of wire and cable conductors. One kilowatt is 1,000 watts.

Table No. 8.—Amount of Division.

Prefix.	Expressed in Words.	Expressed in Figures.	
deci	one tenth	$1 \div 10$	or 10^{-1}
centi	one hundredth	$1 \div 100$	or 10^{-2}
milli	one thousandth	$1 \div 1{,}000$	or 10^{-3}
micro	one millionth	$1 \div 1{,}000{,}000$	or 10^{-6}
bicro	one billionth	$1 \div 1{,}000{,}000{,}000$	or 10^{-9}
tricro	one trillionth	$1 \div 1{,}000{,}000{,}000{,}000$	or 10^{-12}

For example, 1 milliampere is one-thousandth of an ampere; 1 micro-farad (unit of capacity) is one millionth of a farad.

(*To be Continued Next Month.*)

I. E. S. CONVENTION.

At a meeting of the convention committee of the Illuminating Engineering Society held in Pittsburgh, Friday, May 16th, it was decided to hold the next annual convention in that city during the week of September 22d.

Mr. W. A. Donkin of the Duquesne Light Company, was selected as chairman of the local committee on arrangements which will have charge of the convention. Mr. J. C. McQuiston, of the Westinghouse Electric & Mfg. Company, was appointed chairman of the publicity committee and will make all arrangements for advertising the convention.

It is expected that several hundred engineers from all parts of the country interested in lighting in its various forms will be present, and the program, details of which have not as yet been completed, will consist, in addition to the technical sessions, of a reception and dance, several excursion trips and visits to the various industries in Pittsburgh.

ELECTRIFICATION OF CHICAGO TERMINALS

At a recent hearing of the Committee on Railway Terminals of the Chicago City Council on the proposed ordinance for compelling the various railroads entering Chicago to electrify their terminals, a statement was presented by a committee of executive officials of certain important roads interested. The statement presented explains the differences in conditions of railway terminals in Chicago and those of other cities where electrification has already been tried, and asks the committee to defer final action on Chicago electrification until the conclusion of the extensive investigation which has been carried on for the past two years by the Chicago Association of Commerce on Smoke Abatement and Electrification of Railway Terminals.

The statement which was presented for the various roads interested is in part as follows:

"In Chicago the railroad situation is entirely different from that in any other part of the United States where electrification of terminals has been attempted. Chicago has had a phenomenal industrial growth. To keep pace with this growth the railroads have been under the necessity of laying tracks under all sorts of conditions. The demands for service have compelled junction and interchange tracks, grade crossings, elevations, inclines and depressions. The requirements of new industries located in all parts of the city have been and are so irresistible that good engineering and economic operation have been given secondary consideration. As business has increased by leaps and bounds, new tracks, cross-overs and grade crossings have become so numerous that there has grown up a network of steel rails in many localities so intricate and inter-related that only the oldest and most experienced employees now know all the properties of their respective lines. In other cities the railroad companies generally keep to their own properties, but in Chicago there is a peculiarly free exchange of business. The locomotives of one line are permitted to go on the rails of other lines, anywhere that business necessities demand. Coal is supplied for almost daily necessity, with dependable regularity, lumber comes in and is switched to the yards in a few hours, and distributed to the factories with the same dispatch as other and more concentrated raw materials. The orders of jobbing houses, filed one day, are on the road to the consignee the next. Daily trains of merchandise, stock, fruit and vegetables are taken to the congested centers of the city, unloaded, re-shipped or sold locally, in a few hours. The commercial supremacy of Chicago has been brought about through the superiority of its transportation facilities. Unlike New York, with its hundreds of miles of docks and wharves, the merchants of Chicago depend almost entirely upon the railroads for service, and get it. Commerce and transportation are closer together in Chicago than in any other large city in the United States or in the world. It is a shorter distance from the shipping room to the carrier on an average than in any other commercial center, and the business activities radiate to greater distances by reason of such advantages. This unique and peculiar condition of freight terminals, brought about by this rapid growth and the necessity of prompt interchange between railroads, differentiates the condition here from that obtaining in other places where electrification of freight terminals has been proposed.

"The difference is illustrated by New York, which is Chicago's principal competitor, and which has also been frequently referred to as more progressive than Chicago in the matter of electrification. Among the important points of difference between the railroad terminals of the two cities and their approaches are these:

"First: The geography of the city of New York brings the railroad tracks into the terminals through tunnels and along comparatively straight paths, with few crossings and no interchange, whereas in Chicago the tracks converge into the city from nearly all directions, and over many crossings.

"Second: At the present time practically no freight is handled by electricity in the city of New York, and in the two instances where a comparatively small number of freight cars are handled there is no interchange. In Chicago there is an interchange of 25,000 freight cars a day, and 65,000 cars of freight are daily moved into the city. The subject of freight terminal electrification in New York City is now a matter of study, and no conclusions have been reached.

"Third: In so far as electrification has been adopted in New York City, it was necessitated by tunnel conditions and the character of the passenger terminals.

"The foregoing brings us to a suggestion, that the consequence of an erroneous determination of this complex problem, by a superficial consideration, will be most serious to the commercial and industrial interests of this city, and prudence would seem to dictate the wiser course of completing the systematic investigation now well under way by the Association of Commerce. Chicago owes her supremacy, in the competitive race, to the superiority of her facilities for moving freight by rail, and to the extent that these facilities are impaired, her supremacy will be lost to her competitors.

"We, therefore, respectfully request that your committee defer final action upon the pending ordinance until the committee of the Chicago Association of Commerce has completed its labors and prepared its report upon the whole subject matter.

"In the meantime, the railroads are not only co-operating with that committee, but are also co-operating with the Bureau of Smoke Prevention of the City of Chicago, and have made substantial progress in the elimination of smoke. In detail a few of the measures adopted for the reduction of smoke are as follows:

"The organization of a staff of officers, in the city of Chicago, who inspect the operation of locomotives, and instruct the enginemen as to the reduction of smoke;

"The equipment of switching and road locomotives with air jets, superheaters and mechanical stokers.

The use of a better grade of coal;

"The use of improved front end devices, whereby the amount of cinders and dirt carried into the open air has been more than cut in two;

"The construction of new boiler plants, with furnaces built under the recommendation of the City Smoke Department.

"The result, as shown by the official records of the Bureau of Smoke Prevention of the City of Chicago, is a reduction of smoke, from a density of 23 per cent, in 1910, to 7 per cent, in 1912, an accomplishment to which the chief inspector refers as 'a most wonderful and satisfactory improvement.'

"We beg leave to assure your committee that we shall continue to give unremitting and sincere efforts to the elimination of smoke, and to the perfection of plans for the substitution of other power in place of steam."

The statement was signed by: Chicago, Burlington & Quincy Railroad, by D. Miller, president; Chicago &

North Western, by W. A. Gardner, president; Chicago, Milwaukee & St. Paul, by A. J. Earling, president; Pennsylvania Lines, by J. J. Turner, vice-president; Illinois Central, by W. L. Park, vice-president; New York Central Lines, by J. J. Bernet, vice-president; Atchison, Topeka & Santa Fe, by E. P. Ripley, president; Chicago, Rock Island & Pacific, by H. U. Mudge, president.

Indirect Lighting in Railroad Ticket Offices

H. P. KEANE

Just what would be the proper method of lighting a railroad ticket office is necessarily an open question because to date, with a few exceptions, there has been no real standardization of equipment, but the general trend points towards the adoption of indirect lighting. The many installations that have been effected during the past few years show clearly the recognition that is being given the great Conservation of Vision movment.

The study of railroad practice is particularly interesting, and there is a strong human element that predominates when it comes to arranging the interiors of such offices that are dependent upon the public. Perhaps this is because the general passenger agent is usually vested with the power to arrange his departmental equipment in accordance to his own ideas, and it is the touch of individuality that has brought about the marked change that is so noticeable to one who is intimate with the recent developments.

To the casual observer, the interiors of ticket offices speak of evident thought in the arrangement of furnishings. One could almost say that a number of

Fig. 1. Ticket Office of D. & R. G. R. R., Chicago.

the offices present an appearance of having had unlimited money lavished upon them. Mahogany paneling, furniture, etc., seem to predominate, producing a striking appearance, and giving an effect of elegance. The cause of this appears to be the fact that even in the sale of transportation privileges, it is necessary to meet competition, and to do so effectively the tendency is always the same; great developments owe their success to the activity displayed by others, which in a measure reflects and brings about greater activity.

Today, as perhaps never before, the public is being catered to. The comforts are being considered essentials, and the result is undoubtedly, that within a few years' time conditions which today prevail, and are permitted, will be considered entirely inadequate. This is particularly so as regards the illumination, and a realization of the loss of efficiency caused by eye tire and strain will bring about a universal change in the lighting equipment employed.

The indirect method of lighting has given such satisfaction that it is but a matter of time until exposed

Fig. 2. Ticket Office of Union Pacific R. R., Chicago.

light sources will be looked upon as a nuisance, and then will the great number of workers who depend so largely upon artificial lighting, derive the benefits of the development of the science of illumination.

As mentioned in the foregoing, it is impossible to give a general classification under the heading of ticket offices, as each office may be of a certain size and have the general characteristics as would be found in offices of an entirely different nature, so that in devising the method to employ, it is necessary that individual treatment be accorded.

An interesting example of ticket office lighting which is very pleasing and one that has caused a great deal of favorable comment is to be found in the railroad offices located in the Grand Pacific Bldg., Chicago. Arrangements have been made to change over the lighting equipment in all of these offices, and when

the installation is finally completed, there will be presented an entire block having Eye Comfort lighting units producing a very mellow light, with sufficient intensity so that the closest clerical work may be performed without the resultant eye-tire that is so noticeable when operating under direct lighting, and coming in contact with specular reflection.

Figure 1 shows the interior of the Denver & Rio Grande Railroad office. This interior is 16 ft. by 60 ft. with a ceiling height of 20 ft. The walls are of a buff color, and the ceiling is an ivory white. The furnishings and office equipment are of a Santa Fe mahogany, and the private office in the rear is partitioned off from the main part by paneling rising 8 ft. above the floor. There are no individual desk lamps employed and an intensity of approximately 4¾ foot-candles is received through the medium of three fixtures, each taking one 500-watt Mazda lamp. These fixtures are suspended 36 in. from the ceiling, and are equipped with X-Ray E-500 reflectors. The glass blanks of the reflectors are of one piece, plated with pure silver and covered with an elastic enamel to protect the silver from chipping and peeling. The surface of the reflectors is fire-glazed, so as to make cleaning easy. The reflectors are corrugated to afford good diffusion.

In figure 2, showing the interior of the Union Pacific Railroad ticket office, provision was made for stenographic work, so that it would not be necessary to use the general lighting fixtures. Under the balcony two adaptables, each taking 100-watt lamps, were suspended 20 ins. from the ceiling, and so arranged that they could be used independently of any other light source. The private office of Mr. Vaux was equipped with one shallow bowl Eye Comfort fixture of a pleasing and restful design. This fixture has a very flexible arrangement, permitting of the use of one, two, or three 60-watt lamps, so that practically any degree of intensity may be had.

Space does not permit the listing of the ticket offices throughout the country which are equipped by the indirect method. Let it suffice to say that the Michigan Central offices at Detroit, Erie at Chicago and Buffalo, Grand Trunk & Pacific at Winnipeg, Canada, and Canadian Pacific, are a few which shows the tendency towards the adoption of this interesting, economic, and efficient method of lighting. Good lighting is becoming recognized daily as a necessary adjunct to the maintenance of a high efficiency standard, and it is to be hoped in the future that there will be as much attention paid to this one important branch as is given to the other two factors that go to make up the three essentials in modern housing conditions of employees, heating, ventilating and lighting.

Making Shop Repairs to Car Lighting Equipment

GEO. L. ENGLISH

The application of electric light equipment of various types and makes for steam railway car lighting has increased with wonderful rapidity within the past three years. In fact, to such an extent that nearly all sleeping cars and first-class coaches including many mail and baggage cars are ,at the present time equipped with some type of electric light system. The axle device is the most popular and generally used, and this fact has kept the various manufacturers very busy making standard equipments and developing new types with never ceasing improvements. At the shops, where these equipments are applied to the cars, a large amount of attention is given to the applying of the different parts. Many improvements have been made in the wiring, fixtures, switchboards and other apparatus connected with the electric light system which will reduce the cost of maintenance.

The shop electricians as a rule have become experts in this line of work, but to further reduce the cost of maintenance in operating this equipment, it will be necessary for the men to become just as familiar with making proper repairs to the axle device which will insure all parts to be in good, serviceable condition, this work being done while cars are at the shops undergoing class repairs. It has been the general practice in making repairs on axle device on cars, while at the shop, to clean and make necessary repairs on the regulators in the car, proper adjustments, however, not being made at the time. The generator is usually cleaned or repaired in the truck shop or other various places in the shops where the work is more or less interfered with. The armatures and pole changers are taken to the electrical department where they are cleaned and necessary repairs made.

In doing the work in this manner many defects are overlooked so, to avoid this difficulty, the Pullman Co. has adopted plans, whereby all of the various types of axle devices on cars undergoing repairs at shops are removed and brought to the electrical department where suitable apparatus has been installed to facilitate the work of testing and repair. This equipment is shown in the accompanying views of the interior of the axle device repair shop located in the Pullman shops at Buffalo, N. Y.

The practice is to give each axle dynamo and regulator an overhauling after which a running test is made for one hour with 25 per cent overload.

The operation in performing this inspection and repair is as follows: A suitable four-wheel truck which is not as clumsy an affair as is usually found around railroad shops, is used to haul the dynamo and regulators to and from the electrical department. On arrival at the repair benches the dynamo is removed from the truck by means of an air hoist suspended from an overhead track and which travels directly over all the benches and testing racks. The benches are designed to hold one generator each, having a shelf for holding tools, etc., below the top. The dynamos are then taken apart and all parts removed excepting the field coils which are allowed to remain, if in good condition. The interior of the generator frames are blown out with compressed air and cleaned with gasoline; a small squirt can being used for the gasoline, which thoroughly cleans the interior of the generator. After this a coating of P. & B. field coil and armature varnish is applied all around.

The heads, brush rigging and other small parts are thoroughly cleaned, inspected and repaired if necessary. The bearings are bored out and babbitted when worn or badly cut and the shafts are sleeved if worn under size. The armatures are tested in the armature department, the commutators turned down or

smoothed off as may be necessary, in fact every part is put in such a condition that when the machine is assembled all parts of the generator are practically as good as new.

The generator after being assembled and ready for test is removed from the benches as shown in Fig. 1 by means of the traveling air hoist which transfers the dynamo to the dynamo testing racks as shown in Fig. 2. The regulator belonging to that dynamo, after having been cleaned, is also placed on a test rack. The generator supports consist of two wooden blocks bolted to the floor and a Bliss adapter, No. 10049, is bolted to the top of the blocks. Any type of Bliss dynamo will rest securely on this rack and can be belted to the motor and driven at any desired speed. No fastenings or clamps are necessary to hold generator in place. A rack suitable for holding Safety, Consolidated or Gould dynamos is similarly arranged.

Fig. 1. Interior of Axle Equipment Test Room.

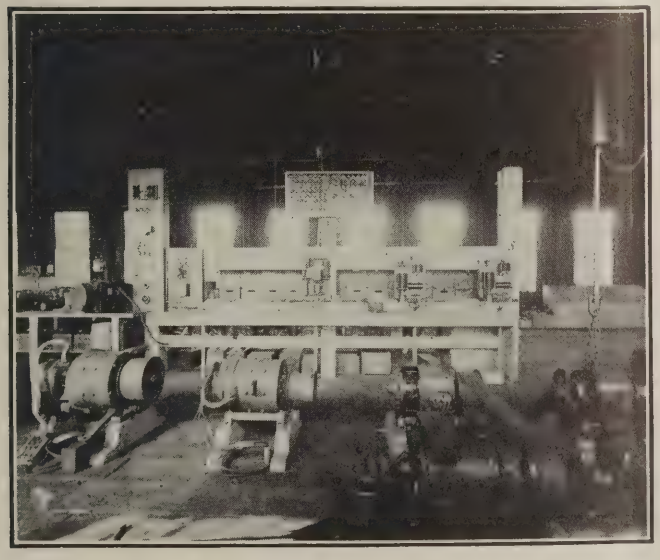


Fig. 2. Regulator Test Rack with Generators in Foreground.

The wiring connections between the dynamo and regulator test racks are so arranged that all types of generators can be connected up quickly with their respective regulators in connection with a bank of lamps having about the same lamp load as that of the average car. The battery charging load is connected to the batteries in the battery department and an overload may be given through connections to a salt water rheostat. All generators are given a running test, the stop charge relay and other parts being then accurately adjusted.

A portable motor is used for driving the generators as it was formerly used to drive the generators under cars in making test after axle lighting equipment was applied to the cars.

Important facts have been learned since adopting this plan of removing the equipment and having it brought where proper repairs can be made. The cost in labor is less, requiring less time; the cost in material is more, owing to the fact that many parts are renewed that should be renewed, but which are not attended to where the work is done in various crowded places throughout the shop. However, on account of this inspection and complete repair in the shops, the cost of maintenance in service thereafter should be considerably less, but what is of greater importance, the possibility of failure of the equipment in service is greatly reduced.

ELECTRICAL INJURIES.

There are a good many minor injuries that can be caused by electricity, such as flashed eyes, flashed skin, contact burns, etc., as well as many of the more serious ones of electrical shock from high tension wires. On the treatment of all these troubles an electrician should be well posted. The little book by Mr. Chas. A. Lauffer, M. D., published by John Wiley & Sons, of New York, takes up this subject in very complete, concise and interesting manner.

NEW BULLETIN ON MERCURY METERS.

The Sangamo Electric Company, of Springfield, have just published a new Bulletin No. 35 on their mercury meters. This bulletin describes in detail the construction of their mercury meter showing various sectional diagrams. It is very well illustrated and more or less technical, but provides some very instructive and interesting reading which is well worthy of attention.

Indirect Illumination of Railway Cars

Although the indirect system has been very extensively employed in the illumination of our offices, homes and public buildings, it has been employed only to a very limited extent in the illumination of railway cars. The installation of an entire train such as is now in service on the N. Y., N. H. & H. R. R., running between New York and Boston, then becomes of special interest. This is the first train to be equipped for indirect lighting throughout.

The train, which is known as the "Merchants Limited," consists of one combination passenger and parlor car, four straight parlor cars, one dining car and one buffet car. The lighting fixtures are clearly shown in the accompanying illustrations and, as can be observed, present a very attractive appearance. On the straight parlor cars, twelve units of 100 watts each are placed in the upper deck and there are seven 50-watt units located in the vestibules and toilets. The total wattage for these cars is 1,305 watts, giving a lamp load of 44 amperes. There are two fans located in opposite corners of the car.

Fig. 1. Interior of Observation Car.

On the combination passenger and smoking car there are eight 100-watt units placed in the center deck and ten 15-watt units located in the passenger compartment, vestibule and toilets, making a total of 950 watts, 32 amperes, load on this car.

In the dining car there are eight 100-watt units in the center deck and twenty-three 15-watt units in the kitchen and pantry and corridor, making a total of 1,145 watts in the diner, representing a lamp load of 36 amperes. There are also five fans in the diner, four located in the main body and one exhaust fan in the kitchen.

In the observation car there are nine lighting fixtures in the center deck in each of which are mounted three 50-watt tungsten lamps. In addition to this there are two single 100-watt units and eight 15-watt units. 150-watt units are located in the center deck of the main body of the car, while two 100-watt units are used in the corridor. In addition to this there are eight 15-watt lamps in the toilets and vestibules. The total wattage of this car is 1,470 watts, representing a lamp load of 46 amperes. The observation car was originally lighted with eleven 100-watt units, but as this seemed to hardly provide sufficient illumination in the observation compartment, the wattage was increased to 150 watts per unit. This later arrangement seems to meet with the entire satisfaction of the traveling public and provides a very effective illumination.

Fig. 2. Interior of Diner.

The center deck panels in each of the cars are finished in a light cream color and the fixture is hung so that the top of the reflector bowl is about 12 in. below the ceiling. The lighting fixtures are spaced at 6 ft. 5 in. apart in single row down the center of the car, there being no quarter deck units employed. The fixtures are about 9 in. deep but vary in other dimensions according to the design of the fixture. The entire lighting effect throughout this train is soft and pleasant, and the contrast of one's feelings upon entering this train, with that of the usual Pullman installation with its glare and bare lamps, or only half shaded lamps, is indeed most pleasing.

The lighting fixtures employed in this installation are of the "Alexalite" type and were furnished by the Central Electric Company of Chicago.

Plans for the original installation provided for approximately 4 to 4½ ft. candles on the working plane 33 in. above the floor. No accurate test data of this installation, however, is available at the present time.

The S. R. B. Ball Bearing for Axle Generators

J. G. COOLEY

EDITOR'S NOTE.

This is the fourth of a series of educational talks on the subject of bearings written by certain authorities on this subject who are connected with some of the various bearing manufacturers.

Train Lighting Sets that give uninterrupted lighting at a reasonable maintenance cost are of real worth to the companies employing this system of illumination. If, however, they fail in any degree to measure up to these requirements they are a source of complaint to the traveling public and a positive nuisance to the roads. Durability and dependability are prime requisites. These characteristics obtain only when the design is safe and sane, and when the construction employs durable, dependable and adequate material.

Of all the parts entering into the construction of an axle driven lighting set, the generator, owing to its location, is called upon to face probably the most severe conditions. Mounted as it is, directly on the truck frame, it receives a continual hammering and vibration, set up by the passing of the truck over frogs, switches, low joints and "holes" in the track. In addition to these hardships there is the uncertainty as to whether the belt tension is what it should be or whether it is many times what is intended. While these characteristics of service are severe on the generator as a whole, at the same time it is the rotating element that is forced to bear the brunt of the pounding and hammering. It is comparatively easy to locate securely and permanently a stationary part. Experience has demonstrated that it is far from easy to control with the same degree of permanence an element that is being carried along at a high train speed while it has at the same time a comparatively high rotative speed about an axis at right angles to the direction of train motion; while it is continually being hurled back and forth in an axial direction by the inequalities in the track and by centrifugal force in rounding curves and while unknown stresses are set up by belt pull and by gyroscopic action.

Wearless bearings are essential for mounting the armature if the severe running conditions are not to destroy the continuity of generator operation; the bearings must be durable and dependable. Obviously, plain friction bearings, depending, as they do, on a thin film of oil and on frequent care and attention, must give way to a bearing that is wearless—a bearing that is frictionless. Good roller or ball bearings are so nearly frictionless as to be practically wearless and so may be considered suitable for this class of service.

The decision as to whether a ball or a roller bearing shall be used is dependent not so much on efficiency as on adaptability, and on a simplicity of design consistent with reliability. The ideal bearing to meet these conditions is the annular type of ball bearing, for it requires no adjustment after it is once installed and if correctly designed will take end thrust as well as radial load, thus eliminating the necessity of separate thrust bearings to meet the axial surging of the armature.

While the annular ball bearing is the ideal bearing for train lighting sets, at the same time, owing to its very nature, it is the most subject to the defects which ultimately result in the failure of either ball or roller bearings. Having in its standard form practically a point contact between the balls and the cone and race, any imperfection in the steel in the path of contact will be picked out and failure of the bearing will result at the defective point. Similarly the balls, carrying their load through what are practically point contacts, must have a high crushing strength, be tough, be absolutely uniform in size, be true in sphericity and have a highly polished glass hard surface absolutely free from imperfections.

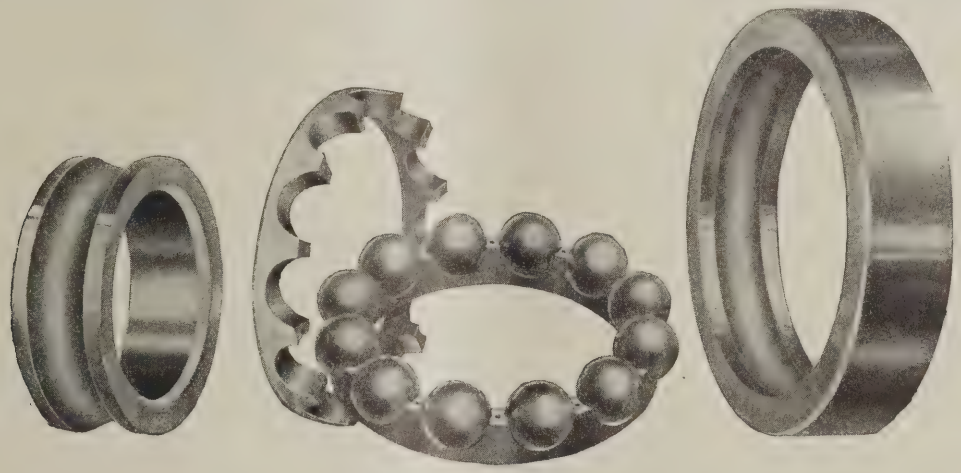


Fig. 1. Showing the S. R. B. Bearing Dismantled.

In order to further increase the factor of safety it has been found very desirable to use the maximum possible number of large size balls. Obviously by increasing the number of point supports and by increasing the crushing strength through these point supports, the radial and axial load capacity of the bearing is also increased. At the same time it is scarcely permissible in this service to use a full complement of balls, for the balls, being in contact with each other, will create friction, since the adjacent sides of each pair of balls are rotating in opposite directions and so have a high relative speed one with another. For that reason a ball spacer should be used. On account of the comparatively high speed to which these bearings are at times subjected and to the other general severe conditions of service, this cage or spacer must be made rigid if durability is to be secured.

The Standard Roller Bearing Co., of Philadelphia, after years of experience in the manufacture of both ball and roller bearings, has found that four things are essential in producing a thoroughly good antifriction bearing:

Correct Design.
Proper Steels.
Correct Heat Treatment.
Accurate Workmanship.

If any of these factors are lacking, an inferior bearing results.

The design of an S. R. B. ball bearing for railway work is shown in the accompanying cuts. The grooves in the cone and race are deep and cut to a radius only slightly larger than the radius of the ball, thus increasing both the radial and end thrust capacities of the bearings. The cage is made up of manganese bronze in two halves rivetted together and contains eleven 1 1/16 in. dia. balls each of which has a crushing strength of approximately 100,000 lbs. These balls lack only about 1/16 in. of being in contact—in other words the bearing contains practically a full complement of balls and so has a maximum factor of safety both for radial and axial capacity.

Fig. 2. Section Through Bearing.

To determine the advantage to be derived by an increased number of balls, tests were run with the same size S. R. B. bearings equipped in one case with eleven 5/16 in. balls and in the other case with eighteen 5/16 in. balls, the bearings in every other respect being the same. The resuts secured were as follows:

Bearing.	No. Balls.	Load.	R. P. M.	Av. Miles.
S. R. B.	11	3,100 lbs.	1,080	97
S. R. B.	18	3,100 lbs.	1,080	1,822

Three stock bearings were tested in each case.

After years of experimentation a crucible chrome alloy steel was selected for S. R. B. Annular Ball Bearings. For the cones and races this is made up in the form of tubing, manufactured by the Becker Steel Company of Germany. For the balls the same alloy comes in rods. In its unhardened state this alloy shows an elastic limit of approximately 50,000 lbs. per sq. in., an elongation of approximately 30 per cent, and a reduction of area of approximately 50 per cent. After proper heat treatment the surface is glass hard and the elastic limit is approximately 300,000 lbs. per sq. in. To insure securing proper steels, every bar received is subjected to careful chemical and physical tests. Manganese bronze was selected for the solid cast cages used on this railway type of bearing, owing to its toughness, its strength, and its wear-resisting qualities. Two solid castings, provided with ball pockets, are rivetted together with heavy escutcheon pins.

All the steels used in S. R. B. bearings are subjected to refined and accurately controlled heat treatments in accordance with a secret process. It is on the character of these heat treatments and the knowledge of how to control them properly that the quality of these bearings depends. The finished steels show a fine, even grain and are especially free from the localized internal strains that, when present, tend to cause rupture when the steel is subjected to working stresses and shocks.

In manufacturing S. R. B. bearings the greatest accuracy is observed. The cones and races are cut from the tubing and grooved on automatic machines, thus bringing them all to the same size. They are then heat-treated, ground on the inside and outside diameters, on the faces and in the grooves. The balls are forged out of the rods, are rough ground, heat-treated, rough ground a second time, finished ground and polished. They are then gauged twice before being sent to the assembling room. Before assembling they are gauged a third time. The bearings when finished do not contain balls that vary more than one-tenth of one-thousandth of an inch in diameter and sphericity. In fact, balls recently taken from a stock S. R. B. bearing by the United States Bureau of Standards were found by the Bureau to vary only from one-quarter to one-half of one-thousandth of

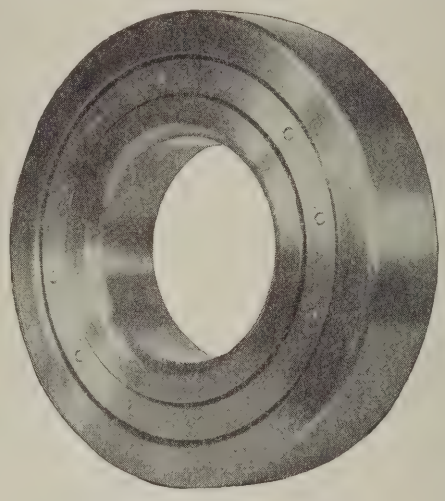


Fig. 3. Assembled Bearing.

an inch in diameter and sphericity. The cages are bored, turned and faced on both sides. The halves are then placed in a jig for forming the ball pocket, and drilling the rivet holes. In this manner the two halves are made exactly alike, thus providing against any binding of the balls when they are assembled in the cage.

After assembling, the bearings are mounted on an arbor and again ground on the outside diameter to make them truly concentric. No bearings are permitted to leave the factory unless they conform to the following standard limits.

I. D. or Bore	+.0002 in.
	—.0003 in.
O. D.	+.0003 in.
	—.0003 in.
Thickness	+.000 in.
	—.002 in.
Eccentricity not to exceed	.002 in.
Balls	±.0001 in.

Some evidence of the importance of finishing bearings accurately is shown in a test recently made by the United States Government on a revolving lighthouse lens. The Government engineers and mechanics designed and made in the Government Shops a type of ball bearing that was finished true to one-thousandth of an inch to two-thousandths of an inch, which was fitted with ordinary commercial balls, purchased from a jobber in New York City, which also varied in size. The Standard Roller Bearing Company was also invited to furnish a ball bearing made true in both plates and balls so that variation was limited to one ten-thousandth of an inch. The lens, measuring about seven feet in diameter and weighing 3,000 pounds, was mounted on a thrust or step bearing, and revolved by weighted clockwork, the rapidity of the revolutions being regulated by the amount of weight used.

The tests made and results obtained were as follows:

(A) Weight required to revolve lens, with ordinary grooved bronze and steel plate thrust and making one revolution in thirty seconds, was 900 lbs.

(B) Weight required for Government ball bearings, one revolution, twenty-five seconds, 123 lbs.

(C) Weight with S. R. B. accurate ball bearing, one revolution, in thirteen seconds, 63 lbs.

(D) Weight with special plates, but ordinary (Government) balls, one revolution, twenty seconds, 73 lbs.

Another test was made to show the pressure required to move it when exerted against the rim or outer circumference of the lens. In this test the Government ball bearing required 64 ounces, but only ½ ounce was required for the special ball bearing and 3 ounces for the special plates and government balls.

The results of the above tests are a fair indication of what may always be expected from accurate finishing of antifriction bearings and explains in part why all bearings manufactured by the Standard Roller Bearing Company are held to such close limits of accuracy.

(Other bearing talks will be given in subsequent issues)

LESSON 17.

GOULD SIMPLEX SYSTEM OF AXLE LIGHTING.

The Simplex system employs a combination of both constant voltage and constant current principles of generator control and was the first of the modern car lighting equipments to be so equipped.

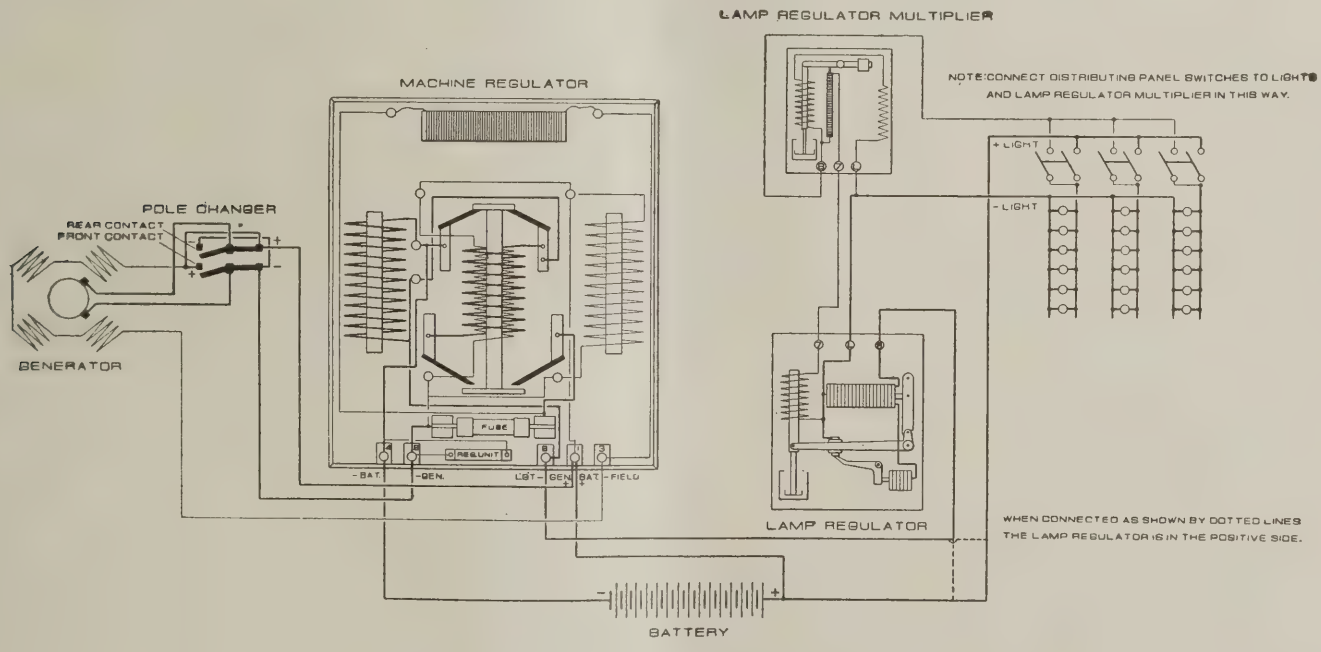


Fig. 96. Wiring Diagram of Gould Simplex System.

Machine Regulator.

When the storage battery is in need of charge, the equipment operates as a simple constant current machine except that since the battery current alone passes through the main regulating solenoid, the machine will operate to deliver constant battery charging current, regardless of either the number of lamps in use or of train speed. As the lamp load is turned on, the generator load will simply increase by an amount equal to the lamp load.

The Simplex System is sometimes furnished so as to provide for other modifications of this principle, however, in which a variable shunt is employed to pass more or less of the lamp current through the series coil of the regulator. This may even be set so that the generator regulator will maintain a constant load on the generator regardless of whether that current goes into storage battery or lamps. This latter arrangement is strictly a constant generator output regulator, while the first mentioned might be more properly called a constant battery current regulator. But, obviously, by adjusting the shunt, any desired combination of these two principles may be obtained in which the generator load would increase somewhat as the lamp load comes on, but this increase would not be equal to the full amount of the lamp load.

The regulator shown in the accompanying diagram and illustrations, however, is of the battery current regulating type. If you follow out this wiring diagram carefully, you will observe that the positive generator connects directly to positive battery and positive lamps, both the machine regulator and the lamp regulator being placed in the negative side of the circuit.

As stated above, the generator regulator consists essentially of two separate coils, one a voltage coil and one a series current coil, either of which, acting through its lever, may control the compression on a pile of carbon discs through which the generator field current passes, and so govern the output of the generator. As explained in previous lessons of this course, where the pressure on such a pile of carbons is increased, the total resistance of the pile decreases,

and when the pressure is released, the resistance of the pile increases. As the train speed increases it causes the generator to revolve faster and tends to raise the generator voltage; this causes a slight increase in battery charging current through the series coil of the regulator which pulls up its plunger and, acting through its lever arm, decreases the pressure on the pile of carbon discs which increases the resistance in the generator field circuit and so decreases the generator field current by just the proper amount to maintain the battery charging current at the proper value.

Similarly on a decrease in train speed, the generator voltage will tend to decrease, allowing the series coil plunger shown at the left of Fig. 97 to fall. This increases the pressure on the carbon pile, decreases its resistance and allows the field current to increase slightly to make up for the decrease in generator speed, and so keeps the battery charging current constant.

It will be noted upon referring to Fig. 97, that the carbon pile, which is located horizontally at the top of the panel, is mounted directly between two pivoted levers, one of which is connected to the plunger of the series current coil and the other to the plunger of the voltage coil. The voltage coil lever presses against the left hand end of the pile, but when the storage battery needs charging, the generator voltage will not be sufficient to pull up the weight of its plunger which will then rest solid on the coil frame and will provide a solid support at the left hand end of the carbon pile. The plunger of the series battery current coil, however, fluctuates up and down with the varying train speed, as explained above, and this, acting through its pivot lever arm, either increases or decreases the pressure on the right hand end of the carbon pile as desired. The equipment at this time operates simply on constant battery current principle of control.

The voltage of the generator is always just slightly above that of the battery and as the storage battery charges, its voltage will gradually rise so that when about three-fourths charged, it will take approximately 40 volts to force normal charging current through it. After this voltage has been reached, the voltage regulating coil shown in the right hand side of Fig. 97 picks up its plunger, and this acting through its pivoted lever arm, releases the pressure on the left hand end of the carbon pile. When this coil acts and releases the pressure on the carbon pile, it of course decreases the generator field current and voltage slightly, causing a rapid tapering off of the battery charging current.

This action is best understood if we simply consider that the magnetism of voltage coil, after the generator has risen to 40 volts, simply replaces a certain amount of magnetism required in the series coil to produce a certain resistance in the carbon pile. Then, since the amount of magnetic pull required in the series coil is reduced, the current flowing through that coil will be proportionately reduced. As the voltage tends to rise above 40 volts, the pull of the voltage coil plunger increases and the voltage coil assumes almost complete control of the generator, preventing the voltage from rising above 42 volts.

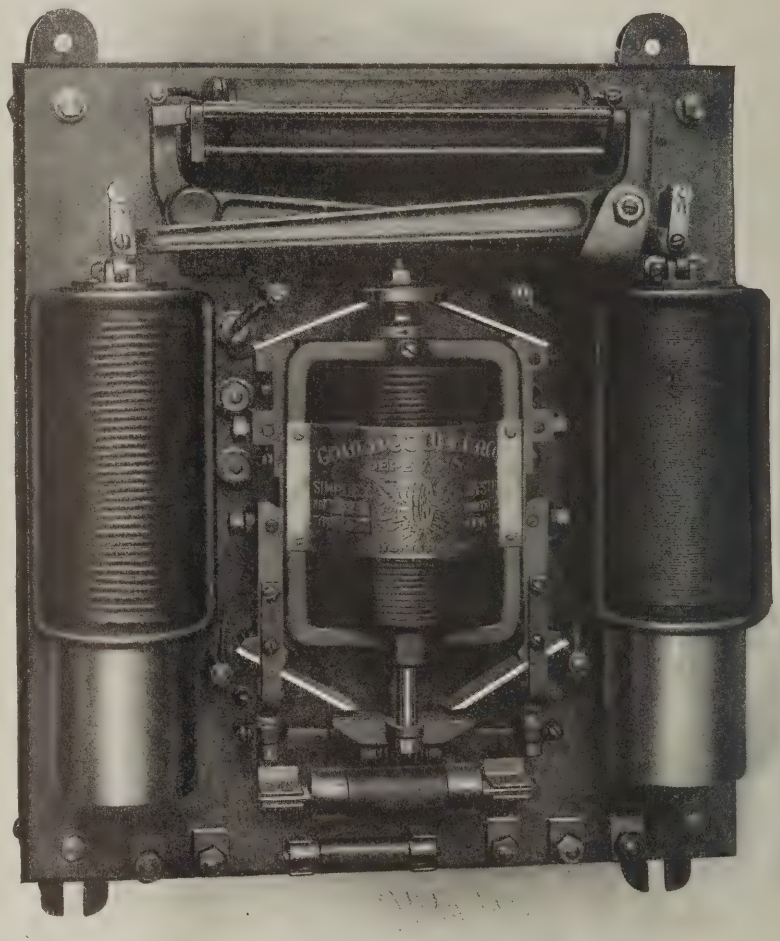


Fig. 97. Generator Control Panel with Auto Switch in the Center.

The generator then acts like any constant voltage machine, delivering just sufficient current for the lamps in use at that time plus a slight charging current. Meanwhile the battery current flowing through the series coil gradually tapers off to low value; the pull of the series coil is very low, so the regulation of the generator is then maintained almost entirely by means of the voltage coil lever acting at the left end of the carbon pile.

Obviously this will greatly decrease the excessive over-charging which has been more or less common in car lighting service. There is no stop charge relay whatever employed on this equipment for the voltage regulating coil has the same function, yet, since it provides a taper charge instead of a cut-off, the uncertainties of operation of the old stop charge relay are largely eliminated.

Another function of the shunt coil is to prevent the generator voltage reaching an excessive value in case the battery circuit should be broken through accident. Even in this case the generator will supply current for the lamps when the car is at or above the cutting in speed.

It might be asked by some: "If the magnetic pull of either the shunt or series coils is strong enough to lift the solenoid plunger at all, why doesn't it draw it all the way up into the coil, just as the automatic switch plunger is pulled up solid as soon as the coil is able to lift it at all?"

The magnetic circuit of the automatic switch is entirely different from that of the regulating solenoid. In the automatic switch there is an iron tail rod fastened to the plunger which, as the solenoid is lifted up, completes the magnetic circuit through the switch frame and causes a great increase in the amount of magnetism, this greatly increases the pull as the switch closes.

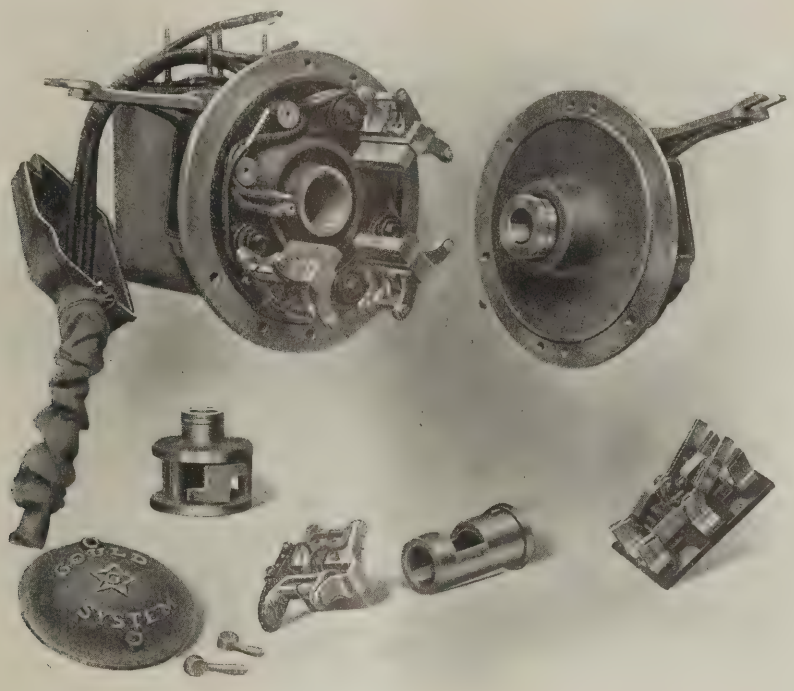


Fig. 98. Dismantled Brush Gear and Pole Changer.

In the regulating coil there is no such tail rod to increase the magnetic pull and the plunger is drawn into the coil by the magnetic lines acting upon that part of the iron plunger farthest outside the coil; and the farther the plunger extends outside of the coil, the greater will be the pull of the magnetism. This same principle applies to all regulating solenoids of other axle equipments. The actual motion of the plunger in the coil, however, is very slight, so that the variation in magnetic pull, due to change in plunger position is small.

In addition to the above-mentioned reason for the plunger not being drawn all the way into the coil, and so greatly release the pressure on the carbon discs, this pile of carbon discs has a certain amount of spring so that, as the plunger rests solid on the frame, the spring of the carbons aids the coil magnetism in lifting the plunger. The higher the plunger is lifted, however, the less this spring force of the carbons becomes.

The solenoids are restrained from oscillation by dashpots and are balanced by the weight of the plungers, thus giving permanent adjustment. No springs or other adjustable devices are employed. Since the generator is controlled within its rating as to current and voltage, the regulation does not have to be adjusted for any particular car run or lamp load. The regulator, once set at the factory, requires no further adjustment.

To insure the prompt building up of the

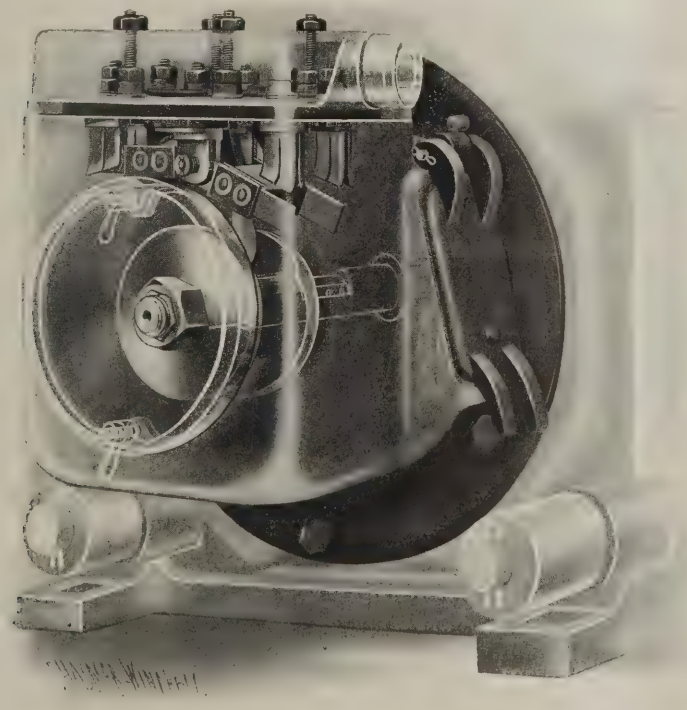


Fig. 99. Phantom View Showing Pole Changer.

generator voltage in case the residual magnetism is lost, or should there be poor contact between the commutator and brushes, there is mounted on the regulator panel, directly below the main fuse, a small resistance unit connected between the battery and the armature circuit. This permits a small amount of current to flow across the armature, which effectually breaks down through the regulating coil.

As the speed of the train decreases, so that the generator voltage falls slightly below normal battery voltage, the battery tends to discharge through the generator; but this reverse current passing through the series coil of the automatic switch causes a reverse magnetism to be developed which neutralizes the mag-

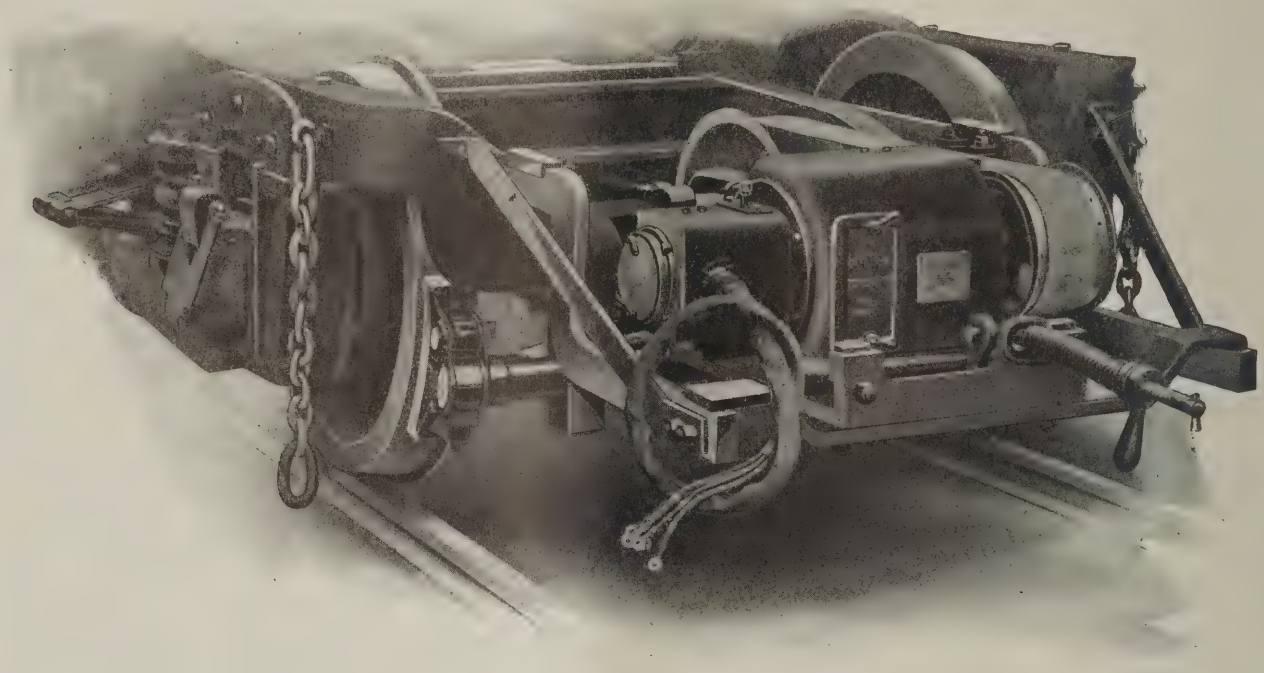


Fig. 100. Gould Generator with Drop Frame Suspension.

any resistance that may exist and makes the starting excitation positive.

Generator.

The generator is of a four-pole shunt wound enclosed type having a cast steel field frame with laminated pole shoes. The more recent generators are equipped with ball bearings throughout, although on the older machines either packed waste or ring oiler were provided, as desired. All the leads from the generator are brought directly to generator terminal box, which makes it possible to entirely disconnect the leads by simply opening the box.

Automatic Switch.

The automatic switch, as shown in the middle of Fig. 97, consists of a compound solenoid winding, the shunt coil of which is placed directly across the generator terminals, and series coil of which is placed in series of the generator. When the voltage of the generator reaches normal value, the shunt coil will be sufficiently energized to pick up the plunger with its tail rod at the bottom; this makes connection between the laminated copper spring contacts shown at the bottom of the switch.

It will also be noticed that there is a duplicate pair of spring contacts on top of the switch frame. When the switch is open, the disc attached to the top of the plunger, short-circuits the heavy series coil of the generator regulator. When the automatic switch closes this short-circuiting contact is broken. This prevents the battery current, which is discharging to the lamp when the auto-switch is open, from passing netism of the shunt coil and allows the switch to drop open.

Lamp Regulator.

The lamp regulator is identical with that described in Lesson No. 13, February, 1913. The main regulator may be carried into either the negative side of the circuit or the positive side, as indicated on the diagram. In the later equipments all three panels, the generator control lamp regulator and switch board panels, are mounted vertically over each other so as to fit in the same locker.

Pole Changer.

The pole changer is a very ingenious device and is shown fairly well in Fig. 99. A double throw switch is placed between the brush leads and the external leads of the generator, and this double throw switch is held in either position by a strong spring actuated toggle. The switch throwing mechanism consists of an eccentrically drilled weight in the form of a "T," pivotally mounted in a carrier, this latter being mounted on the end of the generator shaft. When the direction of train motion is reversed, this weight tips as it passes over the top of its revolution and engages a corresponding lug on the double throw switch, and as the generator continues to turn, this throws the switch so as to reverse the generator connections. If the direction of train motion is again reversed, the generator will turn in the opposite direction and the other "T" side will tip in the reverse direction, causing the opposite projection of the "T" to engage the other lug on the reversing switch, and thus again reverse the generator connections so as to maintain the same po-

larity at all times. As soon as the switch is tripped, its throw is completed by the spring toggle which throws it beyond further contact with the tripping mechanism, until the direction of car movement again reverses.

equipped with 4 k. w. Gould generators.

Where this type of equipment is employed, it is of course unnecessary to provide the usual train electrician or impose train-lighting duties on the baggageman, the only attention given the lighting equipment

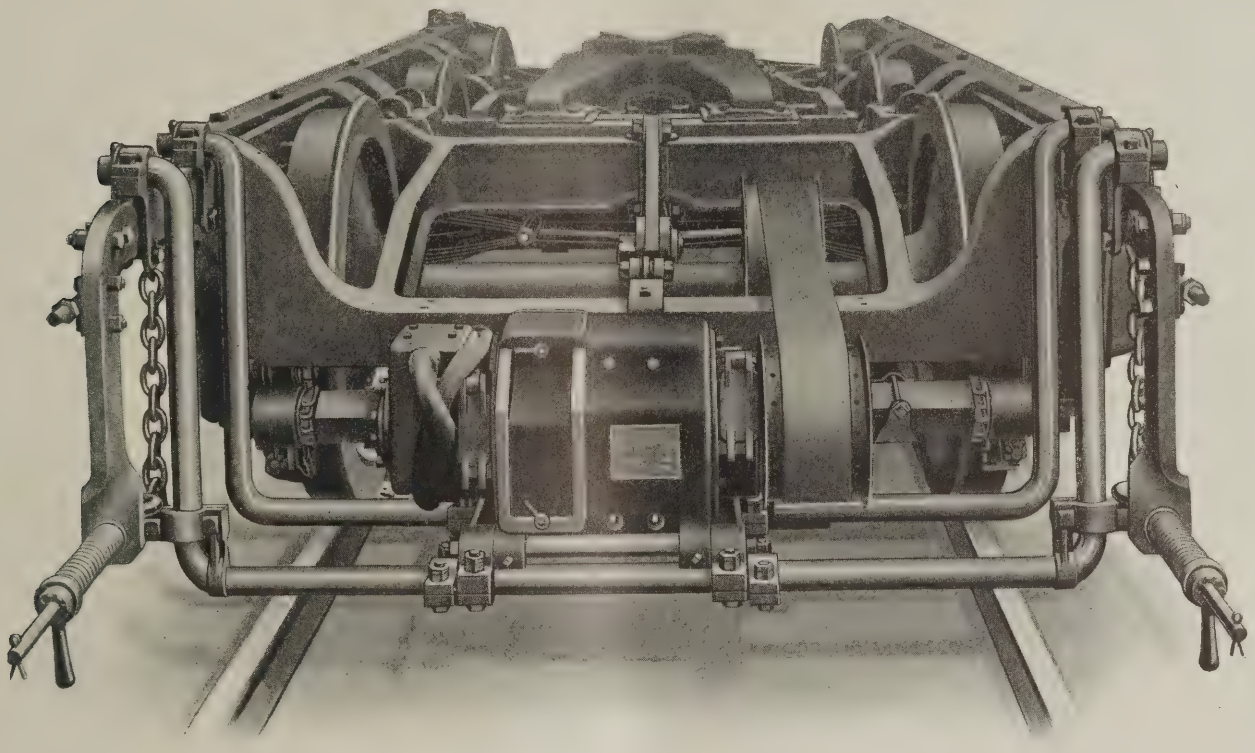


Fig. 101. Gould Generator with Link Suspension.

HEAD-END AXLE SYSTEM

The Northern Pacific Railroad has for a number of years been experimenting with various types of axle-driven generators of sufficient capacity to take care of a whole train. Various devices have been tried out. In some cases the generator has been mounted on the car truck in the usual manner and in other cases located in the baggage car with machine mounted on top of the truck on a steel frame projecting through specially housed openings in the floor, the machine rotating with the truck similar to some types of gas engines and motor mountings in motor cars. Successful results have been obtained with both schemes.

Last fall three trains running between St. Paul and Winnipeg were put into service. These are equipped with Safety standard 4 k. w. generator, belt driven on the axle and mounted directly on the car truck, with standard link suspension.

There are four passenger cars in the train, together with express and mail cars, but these latter are not lighted from the head-end axle system. There are two sets of 200 amp. hr. batteries installed on each of two of the cars; independent lamp regulators are installed on each car and the usual train line connectors put up. The generator regulator is set to maintain constant generator current and, accordingly, the storage batteries are given most of their charge on the daylight run or late at night when most of the lamps are turned off. No light failures have been reported since this equipment was put into service.

There are seven other similar head-end axle equipments being installed on local Puget Sound trains on the road being that of turning on or off the lamps, as desired.

Up to the present time there is no data available as to the detailed operation of this equipment, but we expect to obtain this for publication in an early issue.

Practical Stunts

(*We pay a dollar apiece for each practical stunt published. Send in your ideas.*)

To Test the Depth of the Electrolyte in a Closed Cell.

Take a glass tube about seven inches long and one-quarter inch in diameter, wrap a little tape around one end of the tube, but not over the opening in the tube. The tape will prevent the slipping of the tube in one's fingers.

Place the other end of the tube in the vent hole in the lid, then place finger over the taped end of glass tube tightly and withdraw the tube from the cell. The electrolyte will remain in the tube until the finger is released showing the depth above elements.

J. E. Millard.

Removing Armature Pulleys.

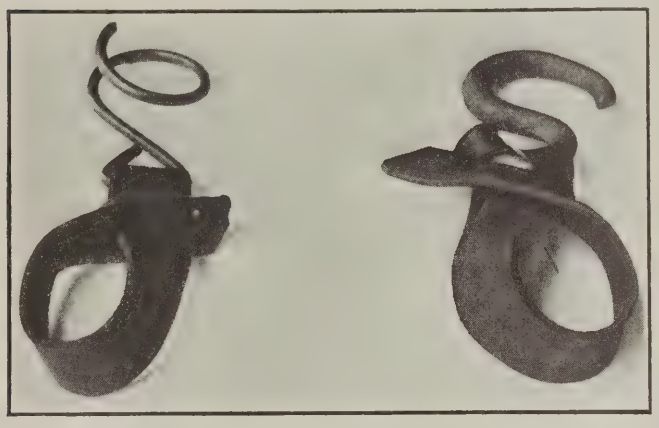
I noticed an article in your practical stunts recently on how to remove an armature pulley, which is very good.

I find that by setting your key way facing you and driving a cold chisel lightly on opposite sides of key way, between head and pulley flange, and having your armature shaft nut worked off about half way, if you hammer on nut the pulley will spring off.

Since I have been doing this stunt I have not broken one pulley flange.

Train Line Connector Carrier.

With the old style cast brass hook on train connection carriers, it is often found that with the motion of the train these carriers become unhooked from the hanger rod above, and the train connector then falls down in the way of passengers. To obviate this difficulty we have made a special hanger as shown in the accompanying photo, which replaces the



New Type Carrier.

old style hook with a double turn of heavy spring wire. To hang this over the rod, the hook is turned sideways and the rod forced between the turns of wire. After the spring hook is properly forced into place, it is absolutely impossible for it to work off the rod. In order to remove the hook it must be turned sideways and the rod forced between the two coils of the spring hook.

It sometimes happens that when the train is parted, the connector is taken down on one car but left up on the other and the connector carrier still left hooked to the first car. With this new style carrier, if this happens, when this car parts the wire connector carrier simply unrolls on the rod and nothing is damaged; but where the old style hook is used occasionally the cables of the connector are pulled out or broken. Jos. Betz, C. M. & St. P. Ry.

Repairing Fan with Stuck Armature.

The other day I had trouble with a Diehl fan armature that was stuck solid. One bearing was badly worn, allowing the laminated armature to rub on the lower pole piece.

Fan bearings almost invariably wear on the lower half of the bearing, due to the weight of the armature, the upper half of the bearing being undamaged. As this bearing was of an odd size, made to fit 9/32 in. bearing, and I had no duplicate bearings in stock, I repaired the trouble by simply turning the bearing housing so that the worn surface of the bearing would be above the shaft. It was, of course, also necessary to reverse the grease cup.—G. C. Elbreder.

Battery Record Plate.

In order to keep accurate track of the battery throughout its entire life, a record plate is screwed to the front of one cell. The plate is cast in a brass die from any old scrap lead and is designed to last the entire life of the battery.

In the upper left hand corner is stenciled the number of the battery, and to the right are the positive and negative signs below which is stenciled the letter showing the kind of elements, i. e., +M would indicate Manchester positives, and —B would indicate box negatives. Below is placed the date the battery went into service, and there is also space below for recording both the dates and the Amp. hr. capacity at each successive cleaning which the battery receives.—J. E. Millard and C. P. Francis.

Question Box

We hope that a large number of the boys will use this "Question Box,"—it is open to all.

Headlight Electrode Fused.

To the Editor:—

A few days ago our man having charge of installing electric headlight equipments on our locomotives used a Schroeder headlight with a Pyle generator and, not being well versed in electricity, and owing to the fact that the Pyle people have the large hole in the positive binding post and the Schroeder in the negative, he crossed the connections; that is, put the positive wire in the negative binding post of the lamp and the negative in the positive. As a consequence, the lamp burned, but allowed so much current to pass through the electrodes that it fused the copper electrode.

Now, I cannot see why it should do it; the pull of the solenoid is in the same direction, no matter from what end the current enters the winding of the solenoid, namely, towards the center; that is, the plunger, or core, would be attracted towards the center of the coil, would it not? I know this trouble never occurs with the ordinary arc lamp, such as is used for industrial and street lighting. Of course it will not give as good light on account of the crater being formed on the lower carbon; the regulation would also be very poor, owing to the bottom electrode being consumed, and it would not be fed up because it is stationary.

V. T. Kropidlowski.

Winona Shops, C. & N. W. Ry.

A. On that matter of the copper electrode fusing when the polarity of the lamp is reversed, you remember from your experience with the direct current street lamps that the positive which is the upper carbon in every case, burns away two or three times as fast as the negative or lower one, and, as you say, the biggest part of the light comes from the positive electrode. This means that the positive electrode gets very much hotter than the negative when the arc is in use.

Now, in the ordinary headlight, the copper electrode is made negative and the carbon positive, and the biggest part of the heating of the arc occurs at the positive carbon electrode. When the polarity of the lamp is reversed, then the copper electrode as positive becomes very much hotter than when properly connected as negative and this causes it to fuse.

Even when connected up with the proper polarity, if the machine speeds up and voltage and current of the arc go too high, the lamp will begin to burn green, and the copper electrode fuse. This is simply because the copper electrode, even as a negative, gets too hot with the current too heavy.

Polarizing Magnet Plungers.

To the Editor:

Q. If we take a piece of hard steel and polarize it, that is, create a north and south pole in it, then insert it in a solenoid, will it then be attracted toward the center of the solenoid, no matter from what end of the winding of the solenoid the current entered?

V. T. Kropidlowski.

A. By polarizing a piece of hard steel and using that for a solenoid plunger, there will be created a north and south pole which will cause the plunger to be repelled instead of attracted when the current is reversed through the solenoid. When the current flowing through the coil becomes so strong, however, that it greatly over-

powers the permanent magnetism of the plunger, it will attract the plunger just as it would a piece of soft steel.

Editor's Note.—The following questions were submitted at a recent meeting of the St. Louis Train Lighting Association:

Q. "Why will a generator with an open field motor in one direction and not in the other?"

A. If residual magnetism in field coil is moving in a certain direction and if the armature moves in the proper direction it will motor but will not generate, but if set in opposite direction, will not motor because it is opposite to residual magnetism.

It seems to me that the answer to this should be something about as follows:

With the belt off it takes but very little power to motor the machine and even with the field circuit open the residual magnetism may be sufficient to cause the generator to turn over when the current is put through the armature. Under these conditions the machine might motor O. K., but of course, would not generate but a very small voltage on the road. The power with which this machine motors, however, is very feeble and even the difference in friction of the brushes or (of the pole changer device might prevent this feeble force from working in one direction).

Q. "What causes the blackening of the incandescent lamps irrespective of whether it is carbon, tantalum or Mazda?"

A. As a rule, a blackened lamp is the result of one of two causes.

First: Operating the lamp at voltage higher than the rated voltage of the lamp.

Second: Operating the lamp for a long period of time. The filament of a lamp which has been operated above its rated voltage will throw off a certain amount of carbon or material from the filament which is deposited on the inside of the bulb.

If you will consider a lamp filament as a bar of iron which is being fashioned by a blacksmith I think you will get the cause and effect very clearly. The blacksmith puts the bar into the fire and brings it up to a red heat. This might be considered to correspond to filament burned at normal voltage. Now, the blacksmith puts the bar back into the fire and increases the heat until the bar comes out at what is known as a "white heat." When the bar reaches the air it is seen that sparks fly from the bar in every direction. These sparks are nothing more than particles of iron which are being thrown off on account of the excessive heat. This corresponds to a filament operated at above normal temperature or above normal voltages.

The increased temperature brings about rapid disintegration of the filament, resulting in the blackening of the inside of the bulb. The above phenomena is especially true of carbon filament lamps.

In metal filament lamps such as Tantalum and Mazda we have to take into consideration the anchor, support wires and the joints, all of which are contributing factors in the blackened appearance of some lamps.

In certain types of Mazda lamp they have introduced what is known as "Getter." This material has been found to very largely overcome blackening in these lamps. It is not found as yet that this "Getter" can be used to any particular advantage in the regular lamp below 60 watts. However, the 15 to 40 watt lamps, as a rule do not show the blackening tendency to the same extent as the higher voltage lamp.

Q. "What is the life of 32 volt Mazda train lighting lamp?"

A. 10, 15, 20, 25 and 50 watt, 25 to 34 volt and 50 to 65 volt train lighting lamp are rated on a basis of 1.23 watts per mean horizontal candle-power, with 1,000 hours as the average total life.

This applies to both the S-19 bulb, which is absolutely the straight side and the G-18½, which is the round type.

The average hours total life is based on an entire installation; in other words, if there are 70 lamps in a car, the average life of the entire installation will be 1,000 hours per lamp.

Motor Talk No. 8

AUTOMATIC REVERSING MOTOR DRIVES.

The increasing application of scientific methods to machine shop operation has brought the use of direct connected electric motors forward very rapidly, and while much has been written and spoken regarding the great saving in power and the increased production, due to this practice, it is doubtful if the true importance of this is fully realized. Usually, the saving in transmission losses is the only thing considered and, even though this may be 50 or 60 per cent of the total power required, it is often only a small part of the real saving. The principal gain is in the increased production and decreased cost.

The use of direct connected motors for machine tools is almost as old as the electric motor, and the application of reversing motors was begun nearly ten years ago, but it is only within the last few years that the automatic reversing direct coupled motor and controlling apparatus have been perfected and placed on a commercial basis. So far, equipments for planers have been developed to the highest degree and these are obtainable from the C. & C. Electric & Mfg. Co., General Electric Co., Westinghouse Electric & Mfg. Co., Triumph Electric Co. and a few European manufacturers. The C. & C. motors are used by the Niles-Bement-Pond Co. who supply about 75 per cent of the planers sold in America today.

Now let us see wherein the direct coupled reversing motor is better than the old fashioned belt drive, even when reversing motors are used. It is obvious that the most efficient tool is the one which will do the most work in a given time without straining either the tool or the work; do it accurately and at the lowest cost for power and maintenance, and with the least loss of time between cutting operations. With tools that perform their work with a rotary motion of either the cutting tool or the work, such as lathes, boring mills and drills, it is possible to make the tool work 100 per cent of the time it is running, but with tools that operate with a reciprocating motion of either the cutting tool or the work, such as planers, shapers and slotters, a portion of the time is lost by the tool when

returning between cutting strokes. So, the relation of cutting stroke and return stroke has an important influence on the amount of work that may be done in a given time.

With the direct coupled automatic reversing drive the cutting and returning speeds are controlled independently, so it is possible to make the ratio between return and cutting speeds anything that may be desired, up to the practical limit. The speeds commonly employed for planing range from 25 to 50 feet per minute for cutting and from 50 to 100 feet per minute for the return stroke, the speeds depending on the work.

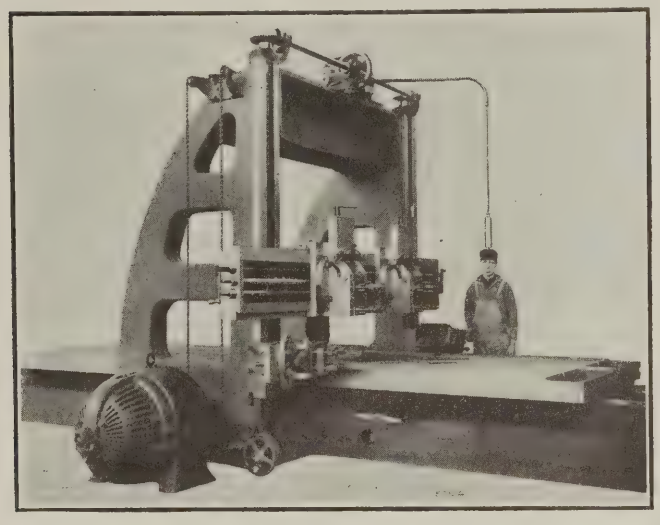


Fig. 1. C. & C. Motor Driving Pond Planer.

From the foregoing it will be seen that the average ratio between return and cutting speeds will be 2 to 1, and motors giving this ratio are easily obtained. But, if a ratio of 3 to 1 is obtained there will be a gain of 12½ per cent in time required to do a given amount of work, and with a ratio of 4 to 1 the gain will be 20 per cent. The latter is hard to obtain, however, unless the planer is made heavy enough to stand this service, on account of the shock produced in accelerating and stopping the platen or table when the speed exceeds 100 feet per minute.

In order to reduce the cutting time to a minimum it is necessary to maintain as high a cutting speed as possible without injury to the work or the tool, so the nature of the work must be taken into account. If the piece is small or sets low on the platen the speeds of both cut and return may be greater than if the piece is heavy or sets high above the platen. The weight of the platen itself must also be taken into account. That it is possible to obtain a ratio as high as 4 to 1 between return and cutting speeds when conditions are right is shown by the fact that the General Electric Co. has a Niles-Bement-Pond planer with a platen 14 feet wide by 35 feet long operating at speeds giving that ratio. It is driven by a 75 H. P. variable speed reversing motor, having a speed range of 1 to 4, which provides cutting speeds from 20 feet to 37 feet per minute and return speeds from 37 feet to 74 feet per minute. It will handle castings up to 16 feet wide by 12 feet high and 35 feet long.

The reason a direct coupled reversing planer drive is so effective is that there is no power wasted in intermediate belts, pulleys or shafts and there is no slippage. Since the power necessary to operate a planer is the sum of the power required to do the work and the power used to overcome the friction and other losses in the driving mechanism, it is evident that, for a given job, a comparison of the no load powers will show the difference between any two systems of drive. The saving made by using direct coupled motors as here described is shown by a large number of comparisons to average over 40 per cent. With a direct coupled motor using dynamic braking, the most common method, the current used on reversals is less than with the shifting belt method because enough must be taken from the line, in the latter case, to stop the planer in addition to that required to start it and run it. With dynamic braking it is only necessary to use energy enough to start and run the planer, the energy developed in stopping the planer being absorbed in the motor armature and the resistances.

The cost of maintenance, where belts are used, must include labor and material for repairing and replacing belts; labor and material for pulley, countershaft and bearing repairs; value of time lost while making repairs; cost of general maintenance, oiling bearings, tightening belts, etc., and maintenance of motor and its controlling apparatus. When direct coupled reversing motors are used the only item to consider is motor and control maintenance.

No accurate general figures can be given as to the time lost in production due to the use of belts because the labor necessary to repair and replace belts varies so in different shops, but we know the productiveness of the tools are increased when reversing motors are applied because there is no belt slippage; no flywheel effect or inertia of pulleys to overcome; the cutting speed is adjustable to suit materials and cuts; the return speed can be adjusted to suit the work; no belts or countershafts are to be repaired, and a large amount of time is saved when setting up the work because the platen may be moved any required amount at will.

In all properly managed shops each machine is made to justify its rentention the same as the employees.

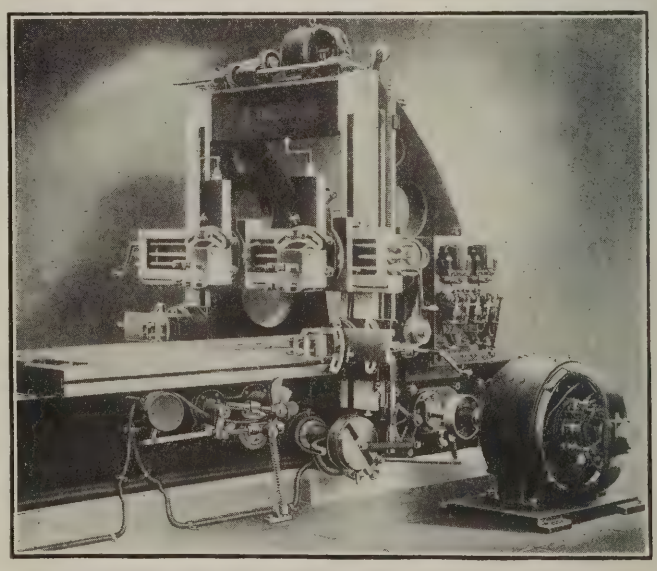


Fig. 2. Triumph Motor Driving Cincinnati Planer.

To determine the value of a machine, the management must work out what is called the "Machine Hour Rate" for each piece of apparatus, and any machine which cannot earn a greater income than that sum is a liability instead of an asset. This "Rate" does not include the wages of the operator, but does include all other operating expenses and is therefore a "fixed charge" which must enter all manufacturing

costs. Table I herewith was compiled by the Westinghouse company and is a typical example of the machine hour rates applying to planers of several sizes, and is based on 2,800 work hours per year with current at 2 cents per k. w. hour.

TABLE I.—OPERATING EXPENSES.

Size of Planer	Int. and Deprec. on Tool Cost	Cost of Pwr.	General Oper't'g Expense	Supervis. & Clerk Work	Total Mach. Hr. Rate
36 in.	.04	.02	.49	.25	.80
48 in.	.12	.02	.59	.30	1.03
56 in.	.09	.04	.69	.35	1.17
60 in.	.18	.04	.70	.35	1.27
7 ft.	.19	.04	1.05	.53	1.81
10 ft.	.28	.04	1.26	.64	2.22
10 ft. Heavy	.82	.06	2.04	1.13	4.05
130 ft.	.22	.06	2.66	1.35	4.29
14 ft.	.60	.06	2.79	1.42	4.87
14 ft. Heavy	.97	.06	3.89	2.14	7.06

Experience shows that where direct coupled automatic reversing variable speed motors have been installed on planers formerly equipped with belt drive the increased production averages 33 per cent. This means that if a shop having three planers should be so busy as to require a fourth one, the cost, floor space and operating expense of the fourth can be saved by equipping the three existing ones with reversing motors and controllers. The cost of three equipments will be about one-half the cost of the new fourth planer, if it is of medium or large size.

It should be noted that the column headed "General Operating Expense" in Table I includes general repairs and replacements, storage, haulage, tool room charges, interest and depreciation on cost of buildings and auxiliary apparatus such as cranes and lights, together with other miscellaneous operating expenses.

In order to insure sparkless commutation when starting, stopping and reversing, under the severe

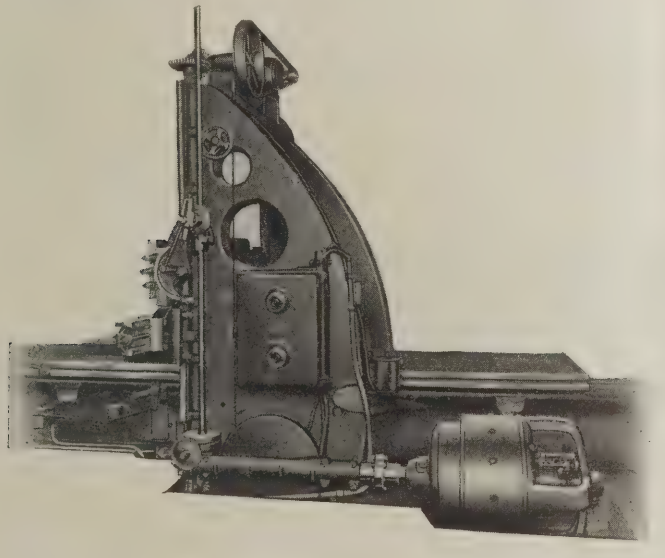
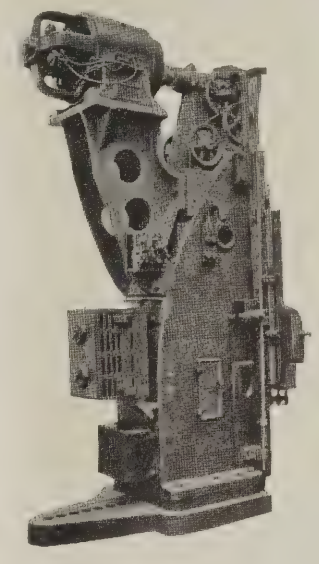


Fig. 3. General Electric Motor Driving Planer.

service conditions imposed, it is customary to use commutating pole type motors. A speed range of 250 to 1,000 R. P. M. is generally sufficient to cover ordinary applications, although a range of 300 to 1,200 R. P. M. is sometimes used on the smaller sizes. The motor is coupled direct to the main driving shaft of the planer in place of the pulleys.

Motor armatures for this service should be of smaller diameter than for other services in order to reduce the flywheel effect or inertia of the moving part. In fact, even with belt drives it is now becoming standard practice to use aluminum pulleys instead of cast iron. One instance has been cited where a 35 H. P. motor armature running at 1,000 R. P. M. had 25 times the inertia of a 15,000 lb. platen moving at 100 ft. per minute. A standard motor with large armature had 46 times the inertia of the platen under the same conditions.

All of the drive and control systems now on the market operate on the same fundamental principles; that is, the motor must accelerate, stop and reverse, and the speed must be adjustable. The planer must also be protected in case of trouble on the power circuit, for if the voltage should go off the platen might run off the bed unless the motor stopped and held it. The essential parts of all control systems are three in number: a contactor panel, a master switch and a resistance. The contactor or control panel is generally bolted to or near the main frame or housing of the planer, with the resistance below or back of it. The master switch is bolted to one side of the planer bed and is operated by dogs on one side of the platen or planer table and operates the contactors which start and reverse the motor. An additional contactor usually cuts the field resistance in and out, and a circuit breaker provides for overload and low voltage protection. The various makers have worked out variations in the details of their equipments, but all follow the fundamentals here outlined.



The first successful reversing motor for this service was developed by the C. & C. Electric & Mfg. Co., of Garwood, N. J., and has been used by the Niles-Bement-Pond Co. on their planers for several years. The motor is positively connected to the table and acts as a powerful dynamic brake at each reversal, producing extreme accuracy of stroke. There is practically no overtravel of the tool, such as would be caused by the elasticity of belts or yielding of clutches. All of the electrical apparatus, except the motor, is mounted in a ventilated metal case located at the right of the housing on the operating side. The motor is on the opposite side, out of the way, and the braking action is so positive that the operator can stop the table instantly by throwing the pilot switch to the off position.

In view of the enormous number of pulleys, belts, clutches, hangers and other parts which may be eliminated, and the great increase in production and the reduction of power and maintenance charges, it is only a question of time before all shops will use reversing motors for all classes of tools operating with a reciprocating motion of work or tool.

Error in Motor Talk No. 6.

In the sixth paragraph on page No. 328 of our April issue there is a misstatement of the situation regarding true and apparent power of an alternating current circuit. The watt meter indication gives us the true power, while the product of the voltage ampere gives apparent power. Watt meter should always be used in measuring power in an alternating current circuit unless you are sure the load is entirely a non-inductive load such as lamps, etc.

Renewable Cartridge Fuses

E. L. EUSTICE

Since the introduction of the cartridge enclosed fuse, there has been a constantly increasing demand for fuse protection at a greatly reduced cost for renewals, which has resulted in the dangerous practice of refilling the standard non-renewable cartridge fuse. This demand demonstrated the absolute necessity for a practical renewable cartridge fuse which provides the necessary protection to electrical equipments and property at a nominal maintenance cost. The practice of refilling standard cartridge fuses, with lead fuse wire or home-made and dangerous fusible elements on the part of users and other than the original manufacturers, usually results in inadequate protection against overloading of the circuits of which the fuses form a part; in fact, may introduce a distinct and additional fire hazard.

The general use of a well designed and properly constructed renewable cartridge fuse, having simple

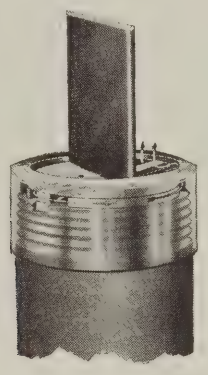


Fig. 1. End of Economy Fuse Showing Air Vent.

parts and low-priced fusible elements, should be considered with favor as tending to reduce the danger from attempts by users to refill standard cartridge fuses. This has long been recognized by the Economy Fuse & Mfg. Co., and for a little over a year and a half their product has been the subject of much comment. Today it is used by thousands of the largest users of cartridge fuses in this and other countries.

All available records of laboratory and service tests indicate that the Economy Renewable Cartridge Fuse is designed on a logical and correct theory. It employs a renewal element of individual form and of definite and accurate rating, and at the same time provides a renewal link which is interchangeable for all capacity limits within the recognized code range of the shell, but not otherwise.

The renewal links are designed with a narrow active portion in the center, which fact causes the burnout to occur in the middle of the shell of the assembled fuse. It is constructed with a liberal sectional area of fuse metal intermediate with its terminals so that it will carry full load without heating, and at the same time the amount of metal to be volatilized when the fuse operates on a disastrous short circuit produces a minimum quantity of gaseous vapor. Its massive terminals dissipate the heat so rapidly that the most vital short circuit does not in any way injure the contact portion of the ferrules or knife-blade members.

The design of the renewal links as mentioned are formed by dies from accurately rolled non-arching fuse metal which insures an absolute uniformity in performance. In service in the fuses, these renewal links always operate at a predetermined time under a given condition, will not hold a sustained arc, and will promptly open a short circuit of almost unlimited capacity without venting of fire or external evidence of operation.

In the ferrule type of fuse the fuse link is inserted in the fibre shell, one end being bent over a slotted washer placed over the end of the fibre shell. A cap is screwed on the fibre shell at this end, clamping the fuse link in position and providing electrical contact between the inner surface of the cap and the fuse link. The fibre shell is then filled with powdered filling material and a slotted washer is placed over the open end. The exposed end of the fuse link is then

Fig. 3. Fuse Link.

bent over the washer and the cap screwed on, thus completing the elctrical circuit. The cap is provided with a tapered opening which exposes the fuse link and the rating stamped thereon. This makes it impossible to defeat the object of the device by inserting a fuse element of improper metal, without detection.

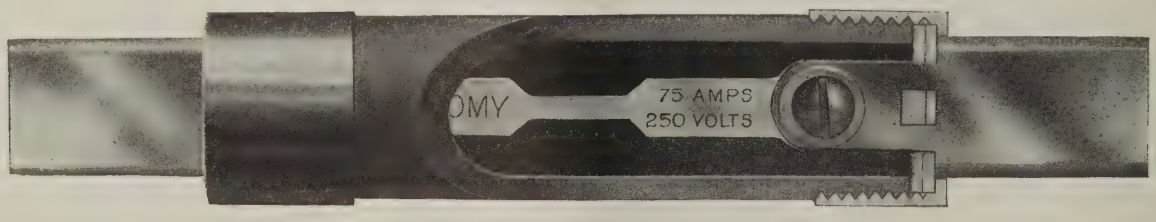


Fig. 2. Economy Knife Blade Refillable Fuse.

In the knife blade type a radically different construction is employed to obtain the essential requirements of this type of fuse, namely: absolute parallel alignment of the copper blades, slight flexibility of blade position, perfect contact between blades and fuse element and general substantial mechanical construction which will withstand the hardest service without appreciable deteroriation or wear.

The first two requirements are obtained by a simple and unique construction consisting of two slotted washers which slide into position through and around the copper blades from opposite sides, the inner washer having a flange on its under side which co-operates with notches milled in the end of the fibre shell to pre-

vent rotary movement of the blades. Perfect contact between the blades and fuse element is obtained without the use of solder by a heavy iron machine screw construction which, combined with ample contact surfaces, insures a good contact and at the same time permits of very easy renewal.

After the washers are positioned on one of the blade members, a small quantity of shredded filler is placed around the narrow portion of the blade immediately under the washers. The entire assembly is passed through the fibre and a shouldered cap is screwed on the fibre shell to hold link and blade assembly in position. The shell is then filled with powdered filler and a small quantity of shredded filler is again applied, and the washers and cap placed in position as in the assembly of the first end. This construction permits of a slight flexibility which insures good contact without respect to the alignment of the clips into which the fuse is inserted, and eliminates heating in fuse terminals that is the cause of many burn-outs.

This construction provides at the same time a very unique vent for escaping gases when the fuse operates. This is obtained by means of the combination of the openings in the slotted washers and the clearance provided between the washers and the cap, so as to form an unobstructed circular and angular path to the open air. In contrast to this means of venting, it will be remembered that non-renewable fuses are provided with a means for venting by a series of holes in the end of the cap which permit an unobstructed path to the open air when such a fuse operates on a heavy short circuit. But in the Economy fuse, the escaping gases are forced through a considerable distance between heavy metal parts and the gases are cooled below their ignition point before reaching the air.

Economy Fuses are now being used by many large steam railways, large corporations and industrial plants, mining and smelting companies, department stores, publishing companies, hotels, office ad public buildings, steamships, various departments of the U. S. Government, etc., and their service in all classes of use seem to indicate that the claims made for the saving in fuse maintenance expense are borne out by the facts. (See table of costs.)

In general a well designed renewable cartridge fuse, having the desired electrical characteristics, is also cheaper to use because of the fact that a large stock of all capacities of renewal elements are available at a very small cost, thus making large stocks of complete fuses unnecessary.

A great amount of time has recently been spent in the discussion of the general subject of the use of renewable cartridge fuses and the matter has been under investigation by the Underwriters for several months, but as yet no final opinions have been given by them.

The manufacturers of Economy Renewable Fuses, however, guarantee that the performance of their product, when assembled with renewal links and filling material supplied by them, will absolutely comply with all of the performance specifications of the National Electrical Code, and complies with all other code requirements except for the renewable feature which is not provided for in the code as it stands today.

Ferrule Type. 3-30 Amperes—250 Volts.

ECONOMY RENEWABLE CARTRIDGE FUSES.

List Price, $0.50 each; discount, 50%; net, each	$0.25
(2 renewal links (without charge) makes no additional cost to replace the 1st and 2nd burnouts)	.00
Total cost of three burnouts	$0.25
Renewal links—List price, $0.03 each.	
Discount, 50%; net cost, $0.01½ each.	
Cost of link to replace 3rd burnout	.01½
Total cost of 4 burnouts	$0.26½
Cost of link to replace 4th burnout	.01½
TOTAL COST OF 5 BURNOUTS	$0.28
Cost of links for next 20 burnouts (20 links at $0.01½ ea.)	.30
TOTAL COST FOR 25 BURNOUTS	$0.58

STANDARD FUSES—NON-RENEWABLE.

List Price, $0.25 each; discount, 50-10%; net, each	$0.11¼
Cost to replace 1st burnout (2nd new fuse)	.11¼
Total cost of two burnouts	.22½
Cost to replace 2nd burnout (3rd new fuse)	.11¼
Total cost of three burnouts	$0.33¾
Cost to replace 3rd burnout (4th new fuse)	.11¼
Total cost of 4 burnouts	$0.45
Cost to replace 4th burnout (5th new fuse)	.11¼
TOTAL COST OF 5 BURNOUTS	$0.56¼
Cost to replace next 20 burnouts (20 new fuses at $0.11¼ each)	2.25
TOTAL COST FOR 25 BURNOUTS	$2.81¼

Knife Blade Type. 101-200 Amperes—250 Volts.

"ECONOMY RENEWABLE."

List price, $2.00 each; discount, 50%; net, each	$1.00
(2 renewal links (without charge) makes no additional charge to replace the 1st and 2nd blows)	0.00
Total cost of three burnouts	$1.00
Renewal links: List price, $0.10 each	
Discount, 50%; net, each, $0.05.	
Cost of link to replace 3rd burnout	.05
Total cost of 4 burnouts	$1.05
Cost of link to replace 4th burnout	.05
TOTAL COST OF 5 BURNOUTS	$1.10
Cost of links for next 20 burnouts (20 links at $0.05 each)	1.00
TOTAL COST FOR 25 BURNOUTS	$2.10

STANDARD FUSES.

If you do not return to maker to refill.	
List price, $0.90 each; discount, 50-10%; net, each	$0.40½
Cost to replace 1st burnout (2nd new fuse)	.40½
Total cost of 2 burnouts	$0.81
Cost to replace 2nd burnout (3rd new fuse)	.40½
Total cost of 3 burnouts	$1.21
Cost to replace 3rd burnout (4th new fuse)	.40½
Total cost of 4 burnouts	$1.62
Cost to replace 4th burnout (5th new fuse)	.40½
TOTAL COST OF 5 BURNOUTS	$2.02½
Cost of new fuses for next 20 burnout (20 fuses at $0.40½)	8.10
TOTAL COST FOR 25 BURNOUTS	$10.12½

NON-RENEWABLE.

If you do return to maker to refill.	
New fuses to begin	$0.40½
Refilling price: List, $0.60 each.	
Discount, 50-10%; net, each. (To replace 1st burnout)	24⅓
Total cost of 2 burnouts	$0.64⅚
2nd refill	.24⅓
Total cost of 3 burnouts	$0.89⅙
3rd refill	.24⅓
Total cost of 4 burnouts	$1.13½
4th refill	.24⅓
TOTAL COST OF 5 BURNOUTS	$1.37⅚
Cost of 20 refills for next 20 burnouts (20 refills at $0.24⅓)	4.86⅔
TOTAL COST FOR 25 BURNOUTS	$6.24½

With the Manufacturers

THE MOON HEADLIGHT.

One of the main features developed in the recent tests by both the Wisconsin Commission and Indiana State Commission, was the fact that phantom lights are sometimes reflected from the roundels of dead signal lamps.

The new headlight developed by the Moon Manufacturing Co., of Chicago, has been designed with particular reference to the elimination of this difficulty. The main control of the light beam is effected by means of an 18-in. inverted lens of the type used in light-house work. This projects a narrow beam of light down the track where it is wanted, and since the lens is placed in front of the arc, there is no direct glare of the arc in the eyes of the approaching engineer. Both arc and incandescent lamps are employed in this headlight, as shown in the accompanying illustrations. The arc is employed when on the road, but when standing on sidings, passing an approaching train on double track, running in yards or when standing in depots, the incandescent lamp can be operated instead of the arc, furnishing quite sufficient light and eliminating all the objections caused by the glare of the arc lamp. The arc, however, provides a high power electric light for road service which is obtained by merely throwing a two-way switch in the cab, extinguishing the incandescents and cutting in the arc or vice versa.

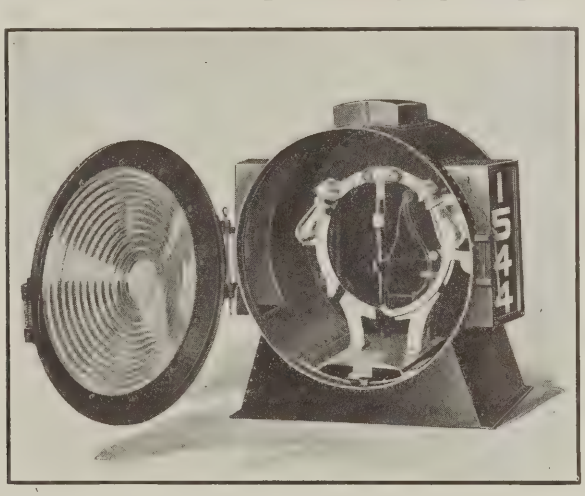


Fig. 1. Headlight with Door Open.

In this headlight there is no parabolic reflector as is commonly used in this service, a concentrating lens alone being employed in front of the arc to direct the light rays in a narrow beam, as mentioned above. This, of course, eliminates the constant trouble and expense of polishing and renewing reflectors, it being simply necessary to wipe off the glass lens.

With the parabolic reflector, the hottest part of the beam is in the center, increasing uniformly toward the periphery and this undoubtedly accounts for a large part of the glass breakage. With a lens, however, the light rays are picked up uniformly and projected therefrom, and the heating effect is uniform and of low value.

In place of the customary carbons, the arc is produced by electrodes, the negative of solid copper and the positive composed of magnetite in a steel tube. This arc of this headlight is then a magnetite flame arc and produces a brilliant white light of constant color. It will burn for 100 hours without renewing the electrodes. In fact, the upper, or negative electrode, will burn for a year or more before it need be replaced.

As is shown on Fig. 3, the entire lamp mechanism is mounted on a sliding base and may be removed from the headlight by releasing an automatic lock. There are three contacts made at the back of the frame, as shown, and when the frame is removed there are no wires disturbed. This frame, as shown in Fig. 2, carries both the arc lamp, incandescent lamp, the resistance unit in series with the arc and the operating mechanism. This latter is simply a balanced arm carrying the lower positive electrode and connects through a movable clutch to the operating plunger of the series lifting magnet.

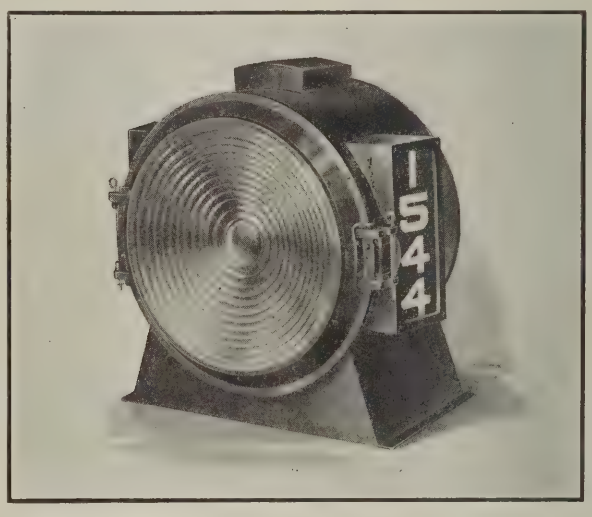


Fig. 2. Moon Headlight.

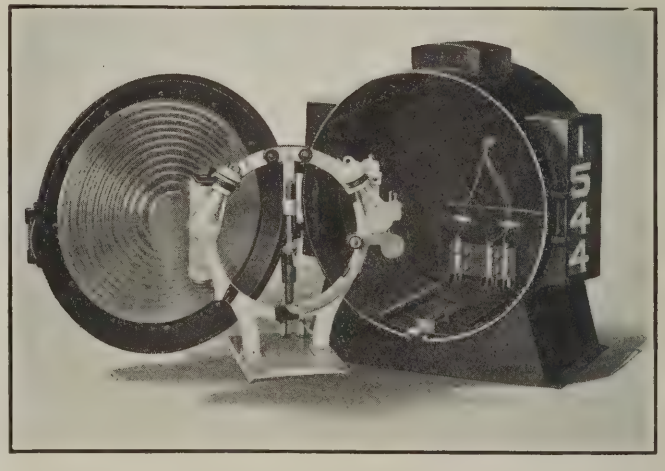


Fig. 3. Headlight with Lamp Mechanism Removed.

The arc once established, this arm is securely locked in place and no amount of vibration can disturb its position. The automatic lock holds the lamp base and frame solidly in place and also provides that good contact be made at the back connections. The lamp frame is of channel section, forming a wire gutter in the back for running the wires around the frame to the lamps.

The projecting lens, as stated above, is mounted on the front door of the headlight; in addition to a spring latch, there is a pin lock on the door which prevents it from coming open. The case is heavy and both dust and water-proof.

The generator is of 1 k. w. capacity and is of standard generator construction throughout The armature is form wound and there is a compound field winding provided which compensates for the variation in load occurring when headlight or marker lights are extinguished. The field coils are mounted on opposite sides

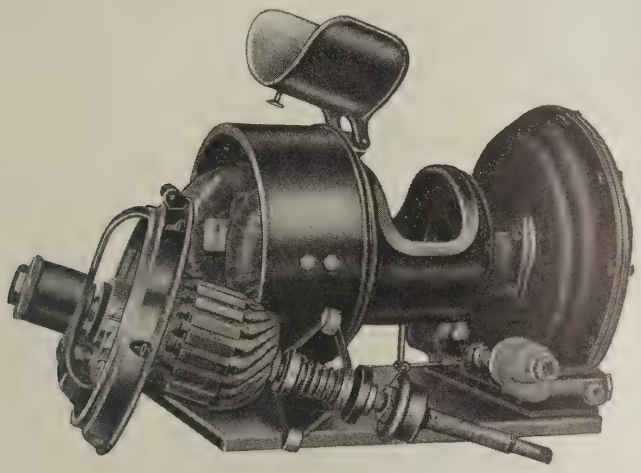


Fig. 4. Generator with Armature Removed.

of the frame and this eliminates the trouble sometimes experienced when oil soaks into the lower field coil and destroys its insulation. The commutator end may be opened for inspection and repair by simply lifting the end housing, as shown. This, when closed, completely seals the generator so that it is both dust and water-tight.

The turbine wheel is of special construction and is rustless pressed steel with a bronze mounting. This combines strength with smoothness of surface, which

Fig. 5. Generator Open for Inspection.

is so essential in turbine contruction where steam passes over metal at a very high velocity. It has been conclusively shown that the higher the polish which can be obtained on the surface of the buckets, the less resistance is offered to the steam passing through it. Steam is emitted from two nozzles 3/16 in. in diameter located on diametrically opposite sides of the wheel, forming a balance of torque which eliminates all stress on the bearing. There are no moving parts in the steam with the exception of the turbine wheel.

The turbine head is provided with a specially constructed opening where the shaft enters it, which eliminates the use of packing entirely.

In case it becomes necessary to remove the turbine wheel, after removing the end housing of the turbine the lock nut on the end of the shaft first loosens the turbine wheel, and upon being unscrewed farther, acts as a puller nut and pulls the turbine wheel from the shaft. Similarly, if it becomes necessary to remove the armature, the retaining nut first releases the armature, then acts as a pusher nut which forces the armature off the shaft.

The governor which operates the control valve is of special design, unique, and exceedingly sensitive in its action. The connections from the governor to the balance valve are of bronze and case hardened steel as shown in Fig. 4. The machine is provided with ball bearings throughout, there being no rubbing contacts with the exception of the brushes on the commutator. The general construction is of circular form, enabling all finished parts to be turned to a true surface, this insuring more perfect fitting and better standardization of parts. The casing is both water and dust-proof and ample provision has been made for easy inspection of parts. On account of the exactness and standardization in manufacturing, which are rigorously maintained, all parts of this equipment are made so as to be readily replaced with new parts to fit accurately.

The equipment operates on from 30 to 40 lbs. of boiler pressure, consuming about 170 lbs. of steam per hour, to maintain the headlight and cab lights. By means of the compound windings of the generator and the accuracy with which the turbine is governed the cutting out of the headlight has no appreciable effect on the cab lights, the voltage remaining practically constant. The equipment operates at the standard voltage of 110, and with a capacity of 8 amperes or 900 watts, although the arc headlight and cab lights consume only about 600 watts.

SAFETY ELECTRIC LIGHT.

This is the title of a new booklet just issued by the Safety Car Heating and Lighting Company describing its new type F machine and lamp regulator and showing, the new type Safety suspension. This pamphlet is written particularly for car lighting men and contains much information of interest and value. It will be sent upon post card request to the Safety Car Htg. & Ltg. Co., 2 Rector St., New York.

RAILWAY CAR VENTILATION.

This is the title of a very instructive bulletin just issued by the Railway Utility Company of Chicago. It takes up the subject of car ventilation from an engineering point of view and shows various designs and operating results of equipment in service. This will be sent upon request to the Railway Utility Company.

RAILWAY UTILITY COMPANY MOVES TO LARGER QUARTERS.

On account of the rapid development of their railway car ventilation and heating business, the Railway Utility Company have recently moved to commodious quarters at 226 S. LaSalle Street. Chicago.

TYPE W LONG LIFE FLAME ARC LAMP.

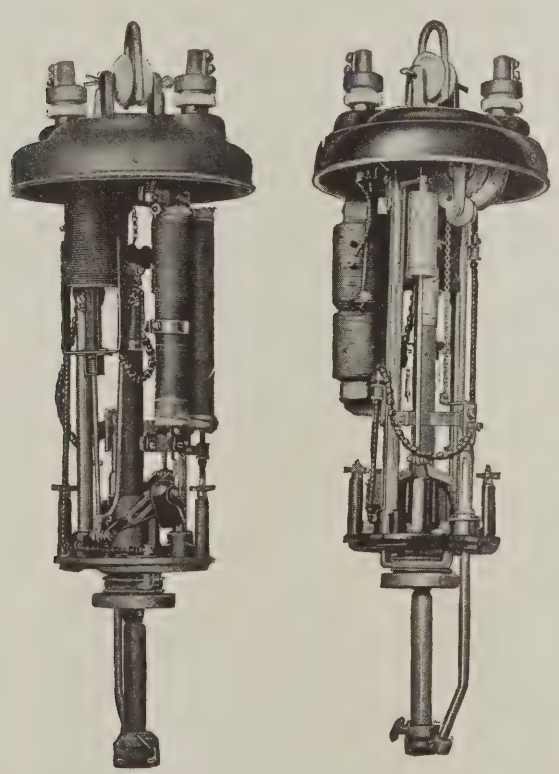
The design of the type W lamp is very simple and the operation of the various parts very effective.

The clutch does not act directly on the carbons in the usual way, but works on the inner machine surface of the roller bearing over which the chain, which connects the upper carbon holder and the lower carbon holder rod, runs, thus making the clutch independent of the size of the carbon.

The lamps are of the focusing design, keep the arc always in the same position and so give a uniform illumination. The focusing rod, which carries the lower carbon holder, is suspended so as to eliminate all friction.

The upper carbon holder is weighted causing the carbons to strike together with great force when starting, effectually crushing any slag which might be on their ends.

A condensing chamber is provided, located above the arc, into which the gases rise, and coming in contact with the cold metal sides of the condenser deposit the powder from the fumes there. The inner globe is protected from cooling by the air space between it and the outer globe which encloses it. Slabs of absorbent material are placed in the condensing chamber to prevent etching of the globes by the fumes.



Views of Flame Arc with Case Removed.

The economizer is so designed that a maximum amount of heat is radiated and a magnetic blow ring placed around the economizer ensures that the carbon burns off square.

The gas cap is very simple and can be removed with ease.

The outer globe is held securely in place by flexible corrugated phosphor bronze strips. No tools are necessary in removing or replacing a globe, while the outer globe may be lowered after it is released by giving the lock a half turn.

The bail for the inner globe is formed into a spring which presses the globe up against a machined seat.

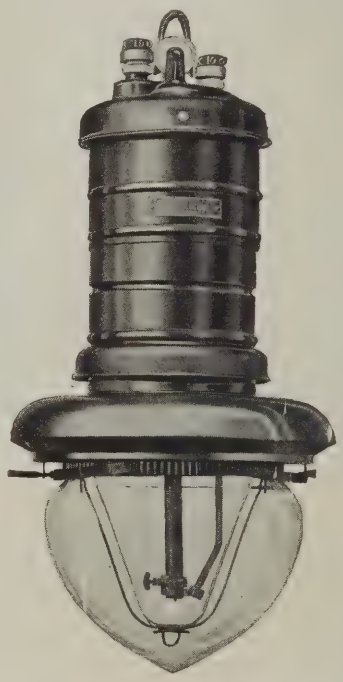
The standard glassware equipment is a clear inner globe with a light alabaster outer globe, but any desired combination of globes will be furnished.

The carbons burn from 100 to 120 hours and then it is necessary to renew one only as the stub of the upper carbon is of the correct length for the lower holder.

The trimming operation is very much simplified.

The casing is of copper, telescopic in action and has a bayonet joint, provided with a lock which serves to retain it securely in position. The casing is both weather and insect proof.

The multiple flame arc lamp is made for use on alternating and direct current circuits of nominally 110 volts,



Type W Flame Arc.

and also for power circuit service, being operated in multiple series on circuits of 220 volts and above.

The mechanism of the power circuit lamp is like that of the direct current multiple lamps with the addition of a regulating weight to properly balance the arc voltages, when two or more lamps are burning in multiple series.

These lamps are designed for operation on circuits of all commercial voltages. The direct current lamps operate at 6.5 amperes, while the alternating current lamps take 7.5 amperes at the terminals, but is equipped with a compensator which raises the current to 10 amperes at the arc.

A highly satisfactory twenty-five cycle arc lamp has also been designed.

All types of this lamp are similar in external appearance and 80 percent of the parts are interchangeable.

The lamp described above is manufactured by the General Electric Company, Schenectady, N. Y.

NEW STANDARD UNDERGROUND PRICE LIST.

A new standard price list on "Sterling" new code rubber covered wire has been issued by the Standard Underground Cable Co., Pittsburgh, Pa. The price list is in convenient and durable booklet form in two colors and gives prices on their "Sterling" wire for bases ranging from 13 to 20 cents for solid and stranded wires of all commercial sizes. Appended are explanatory notes and a list of electric wires and cables and cable accessories manufactured by this company. The price list will be sent on request to the company.

General News and Personal Mention

F. E. Hutchison.

Mr. F. E. Hutchison has resigned his position as chief electrician of the Rock Island Lines, to accept a position as sales manager of the Moon Manufacturing Co., of Chicago. While with the Rock Island, Mr. Hutchison had a wide experience in the operation of electric headlights, and in his new work he will be engaged in the manufacture and sale of the Moon headlight equipment.

"Hutch" was born in Hastings, Neb., back in '81, the year of the big cyclone (this probably accounts for

F. E. Hutchison.

the cyclone). In 1898 he left school to enter the U. S. Navy, where he served an apprenticeship until 1902. During his service he had a wide experience in seamanship, deep-sea diving, gunnery, explosives and electriciy, and at the same time took up a course with the International Correspondence School. After leaving the U. S. service he completed a three-year night course at the Lewis Institute, Chicago.

He has been in railroad service since 1904 on the Pennsylvania, the L. & N. and the Rock Island Lines in the various capacities of electrician, assistant chief electrician and chief electrician of the Rock Island Lines, from which position he has just resigned.

"Hutch" has always been an enthusiastic worker in the Association and a live wire every time there was anything to be 'live about. We are sure we voice the sentiment of his many car-lighting friends in wishing him the greatest measure of success in his new line of endeavor.

Record Output of Electric Railway Equipment.—Ever since last fall the output of The J. G. Brill Company, Philadelphia, has been the largest in the history of the company. As is generally known, the latter is one of the largest builders of electric street-railway cars and trucks in the world. It now has some $4,000,000 of new orders on hand.

Geo. H. Porter Elected President Ry. Materials Association.

Mr. Geo. H. Porter, who has been so active in association matters with the Railway Electric Supply Manufacturers Association has just been elected president of the Railway Materials Association. This is an Association of manufacturers which occupies the same position with relation to the Railway Store Keepers Association that the Railway Electric Supply Manufacturers Association does with relation to the Association of Railway Electrical Engineers.—Success to you, George.

The "Electron."

The "Electron," April cover of which is shown herewith, is an interesting little magazine published by the Central Electric Company of Chicago. Articles are presented which contain much valuable information and it is well worth one's time to read it through. Copy will be sent you regularly upon postal card request to the Central Electric Company.

This Company is also issuing a discount and price book applying to its catalog No. 28. This is full of

Front Cover of the "Electron" for April.

valuable information not only regarding prices, but giving in addition, descriptive matter of a vast amount of equipment and material listed. Copies of this discount and price book will be sent to those interested upon request.

POSITION WANTED—By a man thoroughly qualified to fill position of chief electrician or assistant to electrical engineer. Has had 16 years practical experience in electric lighting and power work, 3 of which have been as division electrician with steam railroad. Has had experience with practically all types of axle equipment and head-end systems. Address W. N. A., Railway Electrical Engineer, Chicago.

The Five Essentials

You Can Tell a "D & W" Fuse At a Glance

They are Different. LOOK FOR →

Four Screws in Each Cap

Safe Indicator
No Exposed Metal

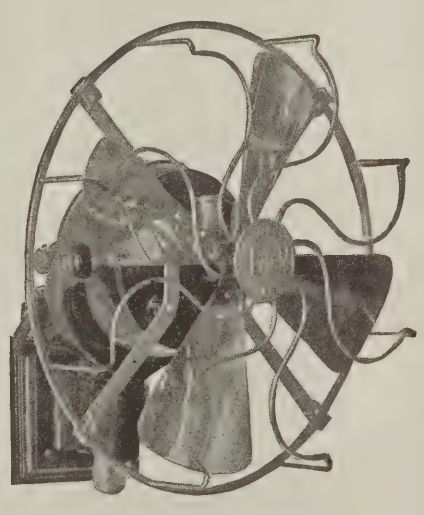
Full Rating on Labels

Extra Heavy Caps and Tubing

Ampere Capacity Stamped in Fibre

Soldered Blades Perfect Alignment

Approved by the National Board of Fire Underwriters



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They are the best. When the manufacturers could no longer improve the motor they improved the base. These bases are of artistic design and may be permanently mounted in the cars. The Fan is easily and quickly removed without disturbing its base. No marring of woodwork—no loss of time.

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OKONITE TAPE is a rubber insulated tape. Joints properly made with Okonite Tape are impervious to moisture and are as strong or stronger electrically and mechanically than the insulated wire itself.

MANSON TAPE is a rubber-filled cloth tape for protecting joints against mechanical injury. It is adhesive, does not unwrap, nor does it corrode copper wire. Is easily handled, economical to use.

Send for booklet, "Economy in Joint Making"

Gain 55% in Light
Save 20% in Power

The Maxolite

Replaces Arc Lamps for Railway Shop and Yard Lighting

WRITE FOR BULLETIN NO. 41

One piece steel enameled bowl, scientific and durable in design.

Low renewal cost; increased efficiency over cluster and arc lighting

Bowl Type With Suspension Fitting

and SERVICE—then write us. We are largest stock of electrical supplies East specialty. If you have *not* our big instruct- asking. Write for it on your letterhead.

ric Company

of Service CHICAGO, ILL.

SOME NEW PASS & SEYMOUR SPECIALTIES.

The Pass & Seymour Company, of Solvay, New York, have recently placed on the market some new equipment which will be of especial interest to railroad men.

Cleat Receptacle No. 4013 as shown in the accompanying illustration is provided with a shade holder groove to take the standard porcelain socket shade holder. No. 9402 is the same as 4013 but is not provided with shade holder groove. Receptacles No. 451, as shown in the accompanying illustration, may be used either on concealed work or on many of the Crouse-Hinds condulets. Socket No. 438, as shown, is what the manufacturers term "electrolier socket with flutolier shell." This is a reduced size of the standard pull socket and is intended for use with fixtures only. They are considerably smaller than the standard socket, thereby permitting a more artistic effect in high priced fixtures.

Receptacle No. 4013.

Receptacle No. 9402.

Socket No. 438.

Receptacle No. 451.

GENERAL ELECTRIC VENTILATED RAILWAY MOTORS.

Bulletin A-4097, recently issued by the General Electric Company, describes in considerable detail that company's ventilated motors for railway service. The fundamental difference between this and previous types of railway motor lies in the method of cooling. In these motors is a definite longitudinal circulation of air through the whole interior of the motor, which cools all the interior parts to an extent heretofore impossible, and effects a considerable increase in service capacity.

These motors can be operated as fully ventilated, semi-ventilated, or fully inclosed motors. The definite air circulation is accomplished by means of a fan which is an integral part of the armature head, in conjunction with longitudinal ducts through the interior of the commutator and armature core.

All sizes of this motor are regularly furnished with a box frame, but the smaller and medium sizes can be furnished with a split frame if desired.

SMALL ACCURATE TESTING METERS.

A very small hand testing meter has recently been placed upon the market by the Weston Electrical Instrument Company of Newark, N. J.

The line of meters includes voltmeters, battery testing voltmeter, volt-ammeter, mili-ammeter, mili-voltmeter ammeter, etc. The manufacturers state that instruments of this type are being successfully used in some of the most severe service, such as being placed on the dashboard of automobiles, where the jar and vibration is very severe.

Battery Testing Meter.

There is a special triple range portable meter made which will indicate any current from 0.05 ampere to 30 amperes and any voltage from 0.02 to 150 volts. A special battery testing voltmeter is provided with a steel point as one of the terminals to make contact with the terminals of the cell to be tested. The other terminal consists of a flexible lead taken from the top of the meter, and it is provided with a point for making contact.

OIL SWITCHES FOR SMALL CAPACITY INDUSTRIAL APPLICATION.

Bulletin No. A4113, entitled as above, and recently issued by the General Electric Company, illustrates and describes that company's Oil Break Switches known as Type F, Forms P3 and P6. The bulletin supersedes the company's previous bulletin on this subject.

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H. G. WILLIAMS, Manager

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Efficiency of Incandescent Illuminants.

With practically all of the illuminants at present available for commercial work the energy radiated is found to include an almost infinite number of wave motions, varying from the longest heat waves, up through the infra-red, the red, orange, yellow, green, blue and violet of the spectrum, and in many cases including also the ultra-violet or invisible waves of extremely short length. The amount of this radiant energy which is useful as light is only that given out at the wave lengths corresponding to the colors of the visible spectrum; and obviously the efficiency of any illuminant is the ratio of the energy given out within the limits of the visible spectrum to the total amount of energy radiated by that illuminant. With an ordinary carbon incandescent lamp there is less than 3 percent of the total energy which is useful as light and with a tungsten lamp which operates at a very much higher temperature there is about 8 percent of the total energy utilized in the production of light.

The higher the temperature of an incandescent body, the greater the ratio of the light energy to the total energy radiated. When an incandescent solid is used as the illuminant, obviously the highest temperature obtainable is the boiling point, or temperature at which that solid vaporizes. With tungsten this is about 3,000 degrees C. and with carbon about 3,600 degrees C., although carbon begins to vaporize at a very much lower temperature which causes blackening of carbon lamps when strained. With incandescent gases, however, the limit to which the temperature can rise is very much higher, when proper space is allowed between the most intensely heated zone and the containing vessel, if there be such.

The force of this point is clearly evident when considering the flaming arc lamp as compared with the old style carbon arc. In the latter case, the biggest part of the light is emitted by the incandescent positive electrode of the d. c. arc or from both carbon electrodes on a. c. arc, and a very small percentage of that light actively comes from the arc itself. With the flaming arc, however, the main illumination is provided by the incandescent gases within the arc itself. With the plain carbon arc there will obviously be a large amount of energy conducted away from the incandescent tips of the carbons and dissipated as heat from the cooler parts, while with the flaming arc lamp where the incandescent gases are located right in the arc itself, this conduction of the energy away from the illuminating zone as heat then becomes largely impossible, and a greater efficiency results.

Although the reason for the higher efficiency of the flame arc is not entirely understood, this heating effect is undoubtedly one of the elements to be considered.

Without doubt the lamp of the future will be one in which the light is generated by an incandescent gas rather than an incandescent solid, partly because of the greater possibilities in heat range and partly because of the peculiar energy radiating characteristics of rarified gases when carrying electrical current.

The Lake Shore Car Lighting Tests.

As announced by L. S. Billau, Chairman of the Illumination Committee of the A. R. E. E. at the recent Atlantic City convention, the car lighting tests which are being conducted at the Collinwood shops of the Lake Shore & Michigan Southern, were started on June 25th. These tests, as outlined by Mr. Billau, are of a most fundamental and comprehensive nature. They will include practically every type of installation employed in car lighting service. The tests will be conducted under the personal supervision of Mr. A. J. Sweet, consulting engineer of the firm of Vaughn, Myer and Sweet, and well known among car lighting men as an authority on illumination subjects.

Special visual preception test apparatus has been designed particularly for these tests and information on this broad and fundamental subject, as well as the comparative data on illumination efficiencies, uniformity, shadows, brilliancy factor, etc., of the va-

rious systems, will be obtained. The laboratory standards of the National Electric Lamp Association will calibrate all lamps, meters, etc., employed in the tests, and in every particular the tests are being conducted with extreme accuracy, so that the results obtained will be thoroughly reliable.

Another point which emphasizes the value of these tests, is their absolute impartiality; they are being conducted under the auspices of the Electrical Department of the L. S. & M. S. Ry., the test crew is composed of both railroad men and various manufacturers' representatives, and Mr. Sweet, consulting engineer of the tests, is not directly connected with either manufacturer or railroad. With high accuracy and absolute impartiality insured, these tests, which include nearly all types of illuminating glassware known, should be of great value to all interested in illumination matters, as well as railroad men.

Friday and Saturday, (July 18th and 19th) will be special visiting days and a large number of invitations have been issued to various railroad men so that this will probably resolve itself into a sort of an informal convention of the Association which will consider the methods being pursued in these tests.

A cordial invitation is extended to all railroad and other men interested to be in attendance at that time.

Semi-Annual Convention of the Association of Railway Electrical Engineers, Atlantic City, N. J., June 16, 1913

MORNING SESSION.

The semi-annual convention of the association was called to order by Vice-President H. C. Meloy, chief electrician of the Lake Shore, at 10 a. m., Monday, June 16th, in one of the parlors of the Hotel Dennis, Atlantic City, N. J.

After a short communicated address by President Cartwright, who was unable to attend personally on account of an accident, Secretary Andreucetti presented his report.

Progress reports of the various committees were then presented as follows:

Committee on Dynamo Suspension:

Mr. E. W. Jansen, electrical engineer of the I. C. R. R., reported that the committee had been working along the same lines as the train lighting committee of the M. C. B. as given on page 59 of this issue.

Committee on Head End Equipment:

Secretary Andreucetti presented a communication from Mr. W. J. Bohan, chairman of the committee, as follows:

Your committee has had one meeting at which all the members were present, and has outlined a complete plan covering the points to be reported in the final report, as follows:

1. A brief historical outline of the development of head end lighting.
2. Descriptions of and service rendered by switchboard apparatus employed by various railroads in their dynamo cars for controlling steam-driven dynamo generator voltage, lamp voltage, charging of storage batteries enroute, etc.
3. Descriptions of and service rendered by apparatus employed by various railroads in their dynamo cars for controlling head end axle and single unit axle driven dynamo generator voltage, lamp voltage, charging of storage batteries, etc.
4. Discussion of the existing rules employed by the various railroads operating steam head end train lighting systems, covering the handling of steam by enginemen, trainmen, train electricians, and messengers or baggagemen handling train lighting equipment.
5. Description of the various methods of maintaining head end train lighting equipment, particularly as regards the upkeep of the mechanical features of steam and electrical units.
6. Description of and efficiency obtained from the various types of steam pipe connections between cars (metallic and rubber) employed by the various railroads.
7. Description of and efficiency obtained from the various types of steam pressure regulators employed by the various railroads.
8. Description of and efficiency obtained from interior steam piping arrangements in dynamo cars employed by the various railroads.
9. Description of and efficiency obtained from the various types of electrical connector supports between cars to hold connectors out of the way of passengers' heads.
10. Brief discussion of recent tests of oil engine driven apparatus and recent turbines other than the General Electric.

The various railroads interested have been written for complete descriptions, with drawings, covering the above, and we hope to obtain such replies from them as will enable the Committee to submit an interesting report at the October meeting.

The Committee will not attempt to go into ancient history, but will bring up points that are new and of interest not only to the Electrical Department but to the Mechanical Department as well.

Respectfully submitted,
(Signed) W. J. Bohan, Chairman,
C. R. Gilman,
E. A. Humphrey,
J. A. Andreucetti.

Committee on Illumination:

Mr. L. S. Billau, of the B. & O., chairman, presented a general outline of what the committee is undertaking to accomplish, as follows:

Your committee was instructed by the Executive Committee to investigate and report at the annual convention of the Association in 1913, on the following:

First: To present a treatise on the more important engineering considerations and principles to be met with in modern illuminating engineering practice.

Second: To investigate the relative merits of the various classes of reflecting and diffusing media from an illuminating engineering and from a practical point of view, with recommended practice for the use of the different types.

Third: To investigate the relative merits of the various arrangements, sizes, construction, etc., of lighting units, with recommended practice, as to the application to the different classes of passenger equipment.

Fourth: After careful consideration as to the scope of the work and to the best form in which to present

the results so as to be of the greatest value to the members of the Association, your committee decided that ultimately the investigation should cover all phases of illumination generally met with in the railway field, and that the data should eventually be published in the form of an illuminating engineering handbook or manual of recommended practice. On account of its magnitude, as well as the rapid changes which are taking place, such a work would require several years to complete. In order to have a definite plan to work on, your committee drew up a brief outline covering the scope of such a work, with the view to recommending to the Executive Committee that, with the approval of the Association, future illuminating committees continue on this work. Such a work would cover, briefly, definitions, the underlying laws and engineering considerations of modern illuminating engineers, and in detail, present data of authoritative investigations and recommended practice pertaining to illumination as met with in its various phases in the railway field, as passenger equipment cars, interior illumination of railway buildings, exterior illumination of yards and station platforms, and other special problems.

On this subject your committee is planning to present in its annual report the following:

First: A brief treatise of the important engineering considerations to be met with in solving properly illuminating engineering problems.

Second: Recommendation for the adoption of standard reflector positions with reference to the lamps, i. e., to standardize the distances between the top edge of the reflector and end contact of base of lamp.

Third: The more important results and recommended practice based thereon of the Baltimore & Ohio postal car illumination tests. While the results of this investigation have been published, it is felt that the data is of sufficient value to justify placing it in the proceedings of the association where it will be readily available to the members.

Fourth: The results and recommended practice based thereon of an exhaustive investigation of day coach lighting to be conducted by your committee.

The day coach tests will be made with the co-operation of the Lake Shore & Michigan Southern Railroad Company and the assistance of manufacturing concerns directly interested in the subject. The tests will be held at the Collinwood Shops of the Lake Shore & Michigan Southern Railroad Company, Cleveland, Ohio, employing a modern seventy-foot coach for the purpose, and will begin officially June 25th, lasting about two months. Mr. A. J. Sweet, of the firm of Vaughn, Myer & Sweet, Consulting Engineers, has been retained as consulting engineer in charge of tests, and will have direct charge of the engineering features of the research. Tests will be made on representative types of gas and electric car lighting equipment fitted with all classes of globes and reflectors suitable for this service. The relative engineering merits of the half-deck and the center deck systems of location of the units will be investigated and also proper spacing of units. The tests will not only include a study of efficiency, illumination intensity, uniformity and shadow questions, but will also, with the more important systems, study the influence of the lighting systems upon eye efficiency and the production of eye strain. It is the hope to make this research of so thorough and adequate a nature that, from an engineering point of view, further researches on the subject will be unnecessary until material improvement shall have been made in the products available for coach lighting.

Group at Semi-Annual Convention, Association Railway Electrical Engineers, Atlantic City, June 16th.

The committee takes this opportunity to invite the members of the Association to visit the tests while they are under way. It is hoped that as many of you as possible will attend, as it is to the material advantage of the committee, by receiving your suggestions and criticisms while the tests are under way, and of yourselves, by obtaining first hand data of the research work.

I might add that the reason for covering this in detail is that the committee is very desirous of securing suggestions and criticisms from the members in order that they may be guided in this work. We are just at a point now where we are beginning on this work and all suggestions will be very gratefully received. (Applause.)

Mr. Edward Wray, of the *Railway Electrical Engineer,* said that the committee was to be highly complimented upon the comprehensive manner in which they were covering the situation, and also for their broad-minded spirit in enlisting the co-operation between railroad men and manufacturers which has made the coach tests and postal car tests possible. It might appear to some that official tests such as these should be performed exclusively by railroad men, and all commercialism be eliminated. On the other hand, however, manufacturers are almost as highly interested in attaining a wide, comprehensive knowledge of the subject, as are railroad men, and in the co-operation

of both railroad men and manufacturers, the tests will be made more valuable than otherwise. They will then consider the subject from the manufacturers point of view, as well as that of railroad men. The committee are to be congratulated on their broad-minded policy in this regard, and the efforts of the manufacturers in assuming a large part of the expense involved should certainly be appreciated by all of us. Perhaps a few of us fully appreciate just what this means—there will be an expense of some ten to fifteen thousand dollars connected with the test, and it is obviously beyond the power of any association to assume such an expense.

President Meloy stated that he hoped a large number of railroad men and others interested would attend the tests as often as possible. He said that Fridays and Saturdays had been reserved as visitors' days, although anyone interested would be welcome at any time.

Committee on Data and Information, and Question Box:

In the absence of Chairman Gilman, chief electrician of the C., M. & St. P., Mr. Edward Wray presented progress report of the committee. He stated that the committee had sent out letters to all of the large railroad companies, requesting information as to the relative importance of alternating current and direct current equipment in railroad shop practice. He stated that the committee expect to have this report cover the conditions of one and two years previous, so as to show the trend of progress of either type of equipment. The committee has also requested information from the railroads in regard to the number and type of lighting units employed in railroad shops, yards and stations. Up to the present time, but three railroads have replied. Such information as has been received, however, is very complete, and providing similar reports are received from other roads, this part of the committee report should be valuable. The committee is also carrying on the work of procuring car lighting statistics in regard to the electric lighting equipment on the various roads. The committee will be very glad to receive any suggestions or requests from members desiring particular information, and will endeavor to co-operate with them in obtaining such information from the railroads. He said that so far, the question box department of the committee had not received proper co-operation of members of the association.

Mr. Geo. A. Stickney, Manager, Lamp Department of the General Electric Company, pointed out the advantages to be derived from a live question box supported by all. He suggested that the committee look into the methods followed by the question box department of the large electric light associations and be guided thereby.

Committee on Lamp Specifications:

Mr. J. L. Minick, chief draughtsman of the Pennsylvania Railroad Company, stated that the present specifications of the committee must be reworded, because of the improvement in lamps and alteration in lamp schedules. He suggested that the association request Mr. Preston S. Millar, President of the Illuminating Engineering Society, to deliver an address on the subject of incandescent lamp specifications, at the annual convention. Mr. Millar has, for a number of years, had charge of the testing of lamps for the associated Edison companies, and has been doing similar work for several railroad companies. Inasmuch as he is not connected with any railroad, nor is he directly connected with any manufacturer, Mr. Millar is in a position to give us an entirely impartial talk on this big subject of testing incandescent lamps. A resolution was presented and passed, unanimously, that such invitation be extended to Mr. Millar.

Committee on Methods of Charging Storage Batteries:

Your Committee, in investigating this subject, deemed it advisable to consider all the methods known to them of charging batteries, treating each method in detail and giving the advantages and disadvantages of each.

The subject was, therefore, divided into three parts, indicative of the service in which the battery is used, viz.:

Straight storage.
Head end.
Axle generator.

STRAIGHT STORAGE.

Methods Employed in Charging Batteries.

(A) Rate of charge and ampere hour input determined by operator based on voltage test on arrival and time available, the charging current being regulated by manipulation of rheostat.

This method of charging, while probably used to a greater extent than any other method, cannot be considered satisfactory. To obtain the best results the following elements must all be considered and proper allowance made for each:

Make and type of battery.
Actual capacity of battery.
Physical condition of battery, with respect to sulphate, density and level of electrolyte, temperature, short circuits, condition of connections, etc.
The rate at which the battery is discharged when determining arrival voltage test and the length of time this discharge continues before making test.
The time that has elapsed between the termination of discharge in service and the time of test for voltage.
The drop in voltage in the battery connectors and in the car wiring from the terminals of the battery to the point at which the voltage test is made, due to the fact that these voltage drops will vary with the class of car on which the battery is in service.
The time available for charging.
The accuracy of the voltmeter itself and the accuracy with which it is read.

It is obvious that many of these factors are unknown quantities to the operator, and, therefore, he cannot give same proper weight. Furthermore, when there are a great number of cars to be charged the charging rate to the battery on each car cannot be followed up sufficiently close.

At the smaller terminals better results could probably be obtained, especially if battery voltage readings are frequently taken during the charge to determine when the voltage has reached a maximum, but the method as a whole is considered unsatisfactory.

(B) Charging current held approximately constant by manipulation of rheostat and state of charge of battery determined by constancy of voltage pilot cell, readings being taken at intervals during charge.

This method of charging is dependent upon: The accuracy with which the voltmeter is read and the assumption that the remainder of the cells are exactly similar in all respects to the pilot cell. It is essential

that when obtaining the voltage readings the charging current be maintained at the same rate and that identical values be obtained with successive readings at least a half hour apart.

It is known that the assumption as made above is erroneous, but nevertheless, if properly handled, this method will undoubtedly result in prolonging the life of the battery over that obtained with the first method mentioned, but it is believed the cost of operation, on account of the amount of labor involved in holding the current constant and in obtaining the successive voltage readings will be excessive.

(C) Charging current held approximately constant by manipulation of rheostat and state of charge determined by constancy of specific gravity of electrolyte of pilot cell, readings being taken at intervals during charge.

This method of charging is dependent upon:

Class of battery.

Temperature of electrolyte, variations of which must be corrected for.

The accuracy with which the hydrometer is read and the care taken to get a representative sample and the assumption that the remainder of the cells are exactly similar in all respects to the pilot cell.

When taking the specific gravity readings it is essential that identical values be obtained with successive readings at least a half hour apart.

Like method (B) it is known that the assumption that all cells in the battery are exactly similar to the pilot cell is in error, but nevertheless, if properly handled, this method will undoubtedly cause less depreciation of a battery in a given time than method (A). However, it is believed that the cost of operation on account of the amount of labor involved in obtaining the successive specific gravity readings would be even greater than with method (B).

(D) Charging current maintained approximately constant by automatic resistance, the resistance being controlled by a thermostat governed by the charging current.

This method of charging is satisfactory in theory (if proper means are provided for terminating the charge), inasmuch as the charging rate can be set at a value which does not tend to produce undue depreciation of the plates. In practice, however, it is not flexible, as in case of cars with short layovers, the rate of charge cannot be increased without adjusting the apparatus to permit higher currents. It has also been found that the thermostat is affected by weather conditions, there being considerable variation in the current flow, without any change having been made in the adjustment, according to the variation in temperature, wind velocity, etc.

(E) Charging current held approximately constant by manipulation of rheostat and ampere input determined by ampere hour meter. This meter so designed as to compensate for the ampere hour efficiency of the battery when the battery is fully charged, acting to complete a circuit through the trip coil of a circuit breaker. This breaker when opened cuts the battery off charge.

This method of charging is dependent upon the accuracy of the meter. The meter should, therefore, be checked for calibration at regular intervals. As an additional check on the meter, voltage and specific gravity readings at several pilot cells should be taken during the latter portion of charge so as to determine that when the meter indicates a complete charge, the battery is actually in that condition. It is believed that this method will give better results than any previously mentioned. In order that the gravity readings may be reliable, the level of the electrolyte in all cells should be adjusted previous to beginning the charge, and the specific gravity of the electrolyte in all cells corrected after charge is completed, allowance being made for temperature.

(F) A definite fixed resistance is placed in series with the battery and a definite constant voltage is maintained across both battery and resistance.

With this method the ampere hour input is determined by an ampere hour meter operating a circuit breaker to cut the battery off charge as in method (E).

Care must be exercised in determining the proper resistance and voltage to use, and especially must the voltage be held very closely approximating the predetermined value chosen. It may be said in general that the higher the voltage chosen (which conditions the use of the greater charging resistance) the greater will be the permissible fluctuation of voltage. Increased voltage, however, increases the amount of energy consumed and reduces the amount of the "taper" effect.

It is believed by your Committee that this system, known as the constant potential system, is the most preferable of the various systems considered for charging batteries operated in straight storage service for the reasons that:

The minimum amount of attention is required from the operator who has only to connect the batteries to the charging plant.

The resistance and voltage being taken at such values as to permit using the highest current rate that will not injure the battery, same will be fully charged in a minimum time, while the current being reduced to normal at end of charge, excessive evolution of gas at this portion of charge is avoided, thus maintaining the efficiency of charge and minimizing the depreciation of the battery.

The elimination of overcharging the battery and so wasting power, as current is automatically cut off on completion of charge.

The results obtained will depend upon the accuracy of the meter and the constancy of the voltage. With regard to this point the remarks under method (D) apply equally well.

This method has the disadvantage that the rate of current flow is affected by the physical condition of the battery, i. e., whether the cells are short-circuited or sulphated by the temperature, level and specific gravity of the electrolyte, age of battery and on whether antimony and certain impurities are present in the cells.

It has the further disadvantages that for the best results it is probable that different terminal voltages and resistance will probably be required for each of the three different types of batteries, viz., Faure, Planté and Edison, although it is believed that very good results will be obtained if the initial charging rate (neglecting the first momentary rush of current) does not greatly exceed the three-hour or double normal rate and the final charging rate does not greatly exceed the normal or eight-hour rate of the Planté battery.

Head End System.

(A) Generator voltage held at predetermined value, dependent upon number of lamps burning, batteries charging or floating or discharging, as the case may be.

This method of operation is considered bad. The batteries, on the several cars, being operated in parallel, there is no information whatever to show what current a battery should receive or what it does receive. The highest voltage at which the generator can be operated, with any regard for the lamps is too low to permit fully charging the battery, so that it is a practical impossibility to maintain the batteries in good condition.

(B) Total charging current to all batteries controlled by manipulation of generator field and line rheostat, and input both of amperes and ampere hours determined by the operator, judgment being based on voltage tests.

The remarks under (A) Straight Storage, apply in this case with even greater force, for the reason that the currents to the batteries on the various cars are not controlled individually but collectively, the batteries being operated in parallel.

(C) Charging current to be controlled by manipulation of generator field and line rheostat (total current depending upon number of batteries on the line) and input to each battery determined by an ampere hour meter automatically compensating for the efficiency of the battery, and the charging current discontinued through the action of a shunt trip circuit breaker controlled by the ampere hour meter, when the charge is complete.

The remarks under Straight Storage (E) apply equally well here. The results obtained would probably not be as good in Head End Service as in Straight Storage, on account of the batteries being operated in parallel and the comparative physical condition of the batteries would greatly influence the actual amount of current to each battery.

It would also require on the part of the attendant close observation of the meters in each of the various cars, so that the total charging current would be reduced as the batteries are automatically cut off the charging circuit.

(D) A definite fixed resistance on each car is placed in series with the battery and a definite constant voltage is maintained across both battery and resistance. The ampere hour input is determined by an ampere hour meter compensated for battery ampere hour efficiency, and when the battery is fully charged opens the charging circuit by completing the circuit through the trip coil of a circuit breaker.

The remarks under (F) Straight Storage apply equally well here as do those under (C) Head End.

In actual operation of (B), (C) and (D), Head End System, it would probably be necessary to operate the batteries and lamps on separate train lines or employ lamp voltage regulators, or else carry a "floating" voltage while lights are being burned and charge the battery at such times as the lamps are not required to be burned.

Axle Generator Service.

(A) Generator voltage so controlled as to maintain generator current practically constant at all times and all speeds above the "cutting-in" speed, current dividing between batteries and lamps according to demand of each.

With this system the output of the generator must be adjusted for the class of car and "Run" in which it is operated, and the season of the year, taking account of the following:

Current capacity of generators.
Ampere hour capacity of battery.
Lamp load at various times, battery charging and discharging and duration of these loads.
Experience has shown that it is not practical to make an adjustment that will take care of these variables and the result has been that batteries operated on this system are invariably over and under charged. One very objectionable feature is the possibility of very high or very low charging rates, without regard to the needs of the battery.

(B) Generator voltage so controlled that current to battery is practically constant at all times and all speeds above the "cutting-in" speed (to do this the generator voltage increasing as the battery becomes charged) current to lamps in accordance with demands, but in addition to the battery current.

This system is preferable to "A", Axle Generator Service, as it is possible to more nearly forecast the condition and make the adjustment to suit. It guards against low charging rates, but there is no protection against over-charging in ampere hours.

(C) Generator voltage so controlled as to furnish a constant current to the batteries at all speeds above the "cutting-in" speed, and in addition to this the current required by the lamps.

To do this the generator must have a rising voltage characteristic as the battery becomes charged and when the maximum voltage is attained the generator is "killed" or disconnected from the battery and the battery discharges until a predetermined low voltage is reached when the generator again begins operation.

The objections to this method are the difficulties of operation which naturally result when attempting to control by voltage methods a make-and-break circuit operating between comparatively narrow limits, and the liability of failure of the generator when the battery is in a discharged condition.

The battery is also required to operate through a greater number of cycles of charge and discharge, and these cycles cover a wider range than other systems, so that it is probable that the depreciation of the battery would be greater than with these other systems.

(D) The charging current is limited to a definite value, and this current is maintained at all speeds above the "cutting-in" speed, the generator supplying in addition the current required by the lamps. As the battery becomes charged the generator voltage rises and when a certain predetermined maximum value is attained the generator voltage is then maintained, the current to the battery decreasing due to the back E. M. F. of the battery.

Assuming that the maximum voltage has been properly selected it will be seen that the battery will be protected against over-charging both in amperes and ampere hours, and also against low charging rates while in a discharged condition.

(E) Current to battery maintained practically constant at all speeds above the "cutting-in" speed until a predetermined maximum voltage is attained, after which the generator voltage is reduced and the battery "floats". The lamp load under all above conditions is carried by the generator.

Providing the maximum voltage attained by the generator at which the charging is terminated and "floating" begins is properly selected, no objection can be raised as to this treatment of the battery.

(F) The generator current is limited to a definite value and this current is maintained at all speeds above the "cutting-in" speed, the current dividing between batteries and lamps, according to the demands of each. As the battery becomes charged the generator voltage rises and when a certain predetermined maximum value is attained the generator voltage is then maintained constant, the current to the battery decreasing due to the rise of the back E. M. F. of the battery.

If the capacity of the battery and generator are

properly related, and the maximum voltage properly determined, this system will guard against over-charging of the battery, but with a heavy lamp load the battery will be, at times, subject to a low charging current when more or less discharged which is a condition that should be avoided with certain makes of batteries.

(G) The voltage of the generator is so controlled that it is held practically constant, the battery "floating", and the current dividing between batteries and lamps in accordance with demands of each.

The difficulty with this system might be the liability of the batteries to lose capacity due to sulphate and other causes, unless provision were made to occasionally charge the battery at a higher voltage.

Ampere Hour Meters.

So far as your Committee is aware, ampere hour meters have never been employed as a means for controlling the charging of batteries in axle generator work, and it is doubtful if a practical scheme employing them in this manner could be evolved.

It is believed that their use as an adjunct to the regular apparatus would be extremely valuable with any of the above methods, as it would provide a check on the treatment of the battery enabling the operator to make adjustments which would result in the best treatment of the battery within the limits set by the balance of the apparatus.

General.

In all of the above systems it must be recognized that any generator which carries the lamp load in addition to a predetermined battery load must necessarily be of a larger capacity than one that is so controlled as to give a certain definite output.

It must also be recognized that no matter how ideally the battery may be charged in theory the results obtained depend upon the reliability of the apparatus to function as called for by the theory.

Your Committee has endeavored to confine the report of the methods that are or may be employed in charging batteries without regard to the reliability of the apparatus or the accuracy with which it conforms to the theory.

Your Committee desires to point out and emphasize the fact, that regardless of the theoretical merits of the systems under consideration, in order to obtain the benefit of these merits in the actual application of the system, and so reduce to a minimum the depreciation of the plates, it is essential that the batteries be maintained in good physical condition, viz: Free from sulphate, buckled or short circuited plates, low level or incorrect specific gravity of electrolyte, etc.

The apparatus supplied for operation under any of the above systems is all designed for a battery in good condition, and the above defects in the apparatus will result in treating the battery in a manner different from what was intended.

Your Committee would recommend the following methods for charging batteries in the three classes of service as being, in their opinion, the most preferable:

Straight Storage—Constant potential with ballast resistance and ampere hour meters and shunt trip circuit breaker on each car.

Head End—Constant potential with ballast resistance and ampere hour meters and shunt trip circuit breakers on each car.

Axle Generator—Constant battery current with voltage control. Ampere hour meter on each car to indicate charge condition of battery and show whether terminal charging is necessary.

Respectfully submitted,

J. R. Sloan, Chairman.
F. R. Frost,
H. C. Meloy,
L. S. Billau,
W. L. Bliss,
W. E. Winship,
H. M. Beck,
H. G. Thompson,
R. C. Lanphier.

Minority Report.

"I do not quite agree with you in regard to the recommended method for charging batteries for straight storage service.

"Undoubtedly, the idea of this report is to outline the method most advisable under average service conditions found around the railroads, and should not be based on theory.

"You state in your report that in recommending the various methods, you are considering a battery which is in good condition and is normal in every respect.

"I believe that a great percentage of the batteries that are actually operated are far from normal and batteries of this class would stand a great chance of getting damaged if charged according to your recommended method for straight storage.

"I have no objection to your recommendation theoretically; but I do believe that in practice it is liable to do more damage than good. I would, therefore, suggest that the recommendation be modified to such an extent as to recommend method F as theoretically the best method, where the voltage of the battery is normal and absolutely known. For practical purposes under general service conditions, method E should be recommended." (Signed) R. Norberg.

(B) Since the report was written a scheme has been worked out for one make of generator, whereby when the ampere hour meter shows the battery to be fully charged, the generator voltage is reduced to the "floating" battery voltage and held there until the battery has been discharged a predetermined amount, when the generator is restored to normal operating condition.

Undoubtedly the scheme could also be applied to other makes, but the attempt to do so has not yet been made. J. R. Sloan.

Mr. Edward Wray stated that the subject of storage battery charging is of the highest importance to railroad car lighting men. When we stop to think that there are over $8,000,000 worth of storage batteries operated by the electrical departments of the various roads, and that the life of those batteries may vary anywhere from one year to eight or ten years, depending almost entirely upon the care which they receive, the importance of seriously considering the subject of this committee report becomes evident.

Under the recommendation for head end service, the report recommends, "Constant potential system with ballast resistance and ampere hour meters and circuit breakers on each car." In explanation of this, Mr. Sloan stated that it will probably be necessary on all head end systems employing ballast resistance, to have a double set of train line circuits, one for the batteries and another for the lamps, with a common return. He stated that the final report would include some results obtained with a yard charging system, designed for constant potential with ballast resistance.

Mr. J. H. Davis, electrical engineer of the B. & O.,

complimented the committee upon the thoroughness with which the report handled this big subject. He was inclined to feel, however, that the recommendation for constant potential with ballast resistance, would not prove entirely satisfactory in head end service. He said that their experience has been that it is absolutely necessary to keep accurate record of the specific gravity of batteries.

In reply to Mr. Davis, Chairman Sloan stated that Mr. Davis had simply emphasized a point which the committee desired to make—that no automatic system, no matter what its theoretical merits may be, can do anything more than to assist in prolonging the life of the battery. Personal care and attention of attendants is an element which cannot be omitted.

He said that if the escape of electrolyte carried off by gasing could be prevented, however, the specific gravity of the battery would be maintained constant. We would have the same gravity at the end of any one charge as at the end of any other. He said that the use of the ballast resistance with ampere hour meters would assist greatly on this point in that overcharging with its excessive gasing would be omitted.

Mr. L. S. Billau outlined the method of storage battery reports employed in their car lighting service, and pointed out that in many cases individual batteries are received in bad condition and require special treatment, and it was his opinion that in such cases the constant potential system would be hardly satisfactory.

Mr. Andreucetti stated that the variation in operating conditions on the various roads were such that a system which might work out entirely satisfactory on one road might not meet the conditions encountered on another road. He said he believed it impossible for all roads to come to the same basis of charging batteries.

Chairman Sloan replied that the most that any committee can do is to make recommendations on a theoretical basis. The various railroads can then take these recommendations and adapt them to their own conditions.

Mr. Wray cited two illustrations—one in which a normal battery would begin its charge at 32 volts and complete the charge at 42 volts, with twice normal current flowing, as recommended by the committee, and the other case in which the battery would start its charge at 28 volts, and might require even as high as 48 volts to complete the charge. In the one, the ballast resistance required would be one-quarter ohm and in the other case, one-half ohm, with a constant charging potential of 52 volts in the first case, and 68 volts in the second case, neglecting line losses.

The committee report was finally accepted as read, with the understanding that the complete report presented at the annual convention would include additional information mentioned.

Committee on Outside Construction and Yard Lighting:

Mr. H. M. Warren, electrical engineer of the D. L. & W., chairman, stated that a preliminary outline of the various subjects the committee intended to cover had been prepared. This is as follows:

OUTSIDE CONSTRUCTION.

Under this heading we wish to consider the following methods of construction:

First: Overhead line construction for yard lighting, and power and lighting circuits to other buildings.

Poles:

Type, wood, steel or concrete; spacing; clearance to tracks; fixtures, kind or type; method of supporting conductor; should all poles be marked as to danger? what safety device, if any, would you place on poles under series lighting, to protect trimmer or inspector?

Distribution:

If high voltage feeder circuits were used, what would be your idea as to location of transformers, method of installing, and secondary distribution.

Second: Underground construction for yard lighting, and power and lighting circuits to other buildings.

What is your idea as to the advantage of underground distribution to overhead, compared with difference in cost?

Conduit:

What type of conduit system would you recommend: wood pulp, tile (single or multiple) or fibre? Explain your reason for using any particular type. What would be your method of installing the different types?

Manholes:

What spacing of holes would you recommend? What type of cover? What would be the minimum size and

Off for a Swim.

shape of hole you would recommend? Would you consider it necessary to drain all manholes? If so, why?

Cables—High Voltage:

What kind of cable would you recommend as to lead sheath and insulation?

Cables—Low Voltage:

What kind of cable or wire would you recommend and insulation of same? Where more than one wire is required for a circuit, would you recommend single conductor? Do you believe there is any advantage in using single conductor in some cases?

Distribution:

What would be your idea for distribution from an underground system?

High Voltage:

Where great distance requires high voltage feeders, what would be your idea or method as to location of transformers, method of installing, and fuse protection?

Low Voltage:

What would be your idea of low voltage distribution as regards to the use, or not, of fuse or cable terminal boxes on branch circuits from mains?

Series Circuits:

What method would you recommend on series circuit in underground systems, as to poles to use for lighting units and terminating cable to these poles.

YARD LIGHTING.

Under this heading we wish to consider the following different methods of lighting, and conditions pertaining to same.

Track Lay Out:

We believe this is the first thing to take into consideration with reference to yard lighting. Very seldom is there any provision made in laying out a yard to leave space for pole clearance where lighting units are required to give the best results.

What are your ideas on this, and how can it be remedied?

Kind of Unit:

What is your idea as to the best lighting unit for yard lighting? Enclosed arc, series or multiple; flame arc, series or multiple; magnatite arc, series or multiple; tungsten arc, series or multiple; quartz lamp.

Spacing, Location to Tracks and Height:

What would be your idea with the use of any of the above type units?

Interference with Signals:

Do you believe lighting units in yards in some places interfere with seeing signals? If so, in such cases what would you recommend to overcome this condition?

Advantages:

Do you believe there is any advantage to a well-lighted yard over one that is not, with reference to damage to equipment and accidents to trainmen? Give your reasons.

General Conditions:

State in a general way what you believe should be observed in yard lighting.

H. M. Warren, Chairman
Jas. B. McIntosh.
W. H. Keirn.
Jos. A. Andreucetti.
C. J. Causland.
C. D. Axtell.

The Same Bunch a Half-Hour Later.

Committee on Standard Reports for Operation:

Mr. E. W. Jansen, electrical engineer of the I. C. R. R., stated that the committee had considered the matter, but as yet had not agreed on any definite set of reports.

Mr. Meloy pointed out the importance of systematizing reports on car lighting equipment.

Commission on Wire and Cable Specifications:

Secretary Andreucetti read a communication from Mr. W. A. Del Mar, chairman, New York Central, as follows:

"The committee has had three regular meetings and has conducted considerable business by correspondence. The work accomplished to date is as follows:

(1) Raising the limit of the 1912 specifications from 600 to 2,500 volts.

(2) Securing the co-operation of the American Electric Railway Association, with the view of having the two associations adopt similar standards.

(3) Preparation of tentative specifications for varnished cambric insulation, for voltages from 2,500 to 25,000 volts.

(4) The completion of tests preparatory to the preparation of specifications for impregnated paper insulation, same voltages.

Sloan and Stickney Negotiating a Roller, with Skep Swamped in the Distance.

Off for Some Deep-Sea Fishing.

Doane on Parade.

(5) The committee has every prospect of completing its work in time for the fall convention. All of the members have shown commendable activity and the manufacturers not represented on the committee have freely given their assistance.

Yours very truly,

(Signed) Wm. A. Del Mar,
Chairman."

AFTERNOON SESSION.

Paper on the Gas Electric Car:

Mr. Samuel T. Dodd, of the General Electric Company, read a very interesting paper on this subject, which was accompanied by a large assortment of lantern slides. Mr. Dodd reviewed the development of the self-propelled passenger car, beginning from efforts as far back as 1847, on the part of certain European railways.

In consideration of the fact that the steam engine combination passenger cars have only one drive axle, their tractive power is very low. The radius of action, because of their limited fuel and water supply, is also low.

He also reviewed the development of the compressed air car and the storage battery car. In a compressed air car, having a capacity of 1,000 gallons of air, compressed to 2,000 lbs. pressure, the operating radius of the car is only about fifteen miles. With the development of the storage battery car recently, the radius of this type of car has been greatly extended. The speaker said that without a doubt, the storage battery car has a definite place to fulfill. He spoke of the storage battery cars operating on a railroad from Havana to the beach, which are giving very satisfactory service.

He reviewed the development of the gasoline motor car, and said that much credit was due the McKeene Motor Car Company for the advance that had been made in this equipment. He then described the gas electric car manufactured by the General Electric Company, which consists of a gasoline engine mounted in the cab, direct connected to a generator, the voltage of which can be adjusted to the proper value required to drive the car at a certain speed. Motors are mounted on each of the trucks, which receive their power from the generator. The gasoline engine then runs at full speed and normal output at all times regardless of whether the car is starting or at high speed.

The speaker then showed a series of slides illustrating the various stages in the development of this car by the General Electric Company.

Illuminating Engineering Co-operation.

Paper by G. H. Stickney.

It is my privilege to address you for a few minutes, as a representative of the Illuminating Engineering Society, with the hope of bringing about a cordial co-operation between the organizations we represent with respect to their common cause; namely, the advancement of Illuminating Engineering practice on railways.

The day of close trade secrets is waning and the mutual advantage to be obtained through the interchange of experience has been effectively demonstrated. In carrying out this principle, Dr. A. Kennelly, President of the Illuminating Engineering Society in 1911, appointed a Committee on Reciprocal Relations with other societies. The work of this committee has been so successful that the original committee has been continued by the succeeding administrations. The object of the committee, as its name implies, is to promote the establishment of co-operative relations with other similar organizations interested in illumination.

For the benefit of those who are not members of the Illuminating Engineering Society, I would say that the Society was founded in 1906, and has for its purpose the advancement of the Art and Science of Illumination. Sections in New York, Boston, Philadelphia, Chicago and Pittsburgh meet monthly, except during the summer season, and the convention of the entire society is held once a year. The convention for 1913 is to be held in Pittsburgh September 22nd to 25th. At these meetings papers on all phases of illuminating engineering are read and discussed, and the more important papers, with the discussion, appear in the Transactions of the Illuminating Engineering Society, which are issued monthly. As would be expected, these transactions form a very valuable record of the important theoretical and practical knowledge concerning the application of light.

In addition to this, the Society has a number of active general committees, of which the following are some of those devoted to technical work.

The Committee on Research: This Committee keeps in touch with illuminating engineering research and suggests lines along which further investigation is desirable.

Group in Front of Safety Booth.

The Committee on Illumination Primer: This Committee has issued an educational text book "Light, Its Use and Misuse." This publication has for its object the education of the public with regard to the use or light. It has run through several editions, and an edition of several hundred thousand is now being prepared.

The Committee on Progress: This Committee reports at each convention the most important advances in lighting for the year.

The Committee on Glare from Reflecting Surfaces: This Committee is making a study of the deleterious effects of glare, with a view to securing improved conditions especially for those who work over the written or printed page.

The Committee on Nomenclature and Standards: This Committee in acting with similar committees of other organizations toward the standardization of units, terms, etc.

Committee on Collegiate Education: This Committee has co-operated to secure the establishment of effective courses in Illuminating Engineering. This work is indirectly an outgrowth of the well-known course in Illuminating Engineering which was held in

Baltimore in 1910 under the auspices of Johns Hopkins University and the Illuminating Engineering Society.

Committee on Popular Lectures: This Committee has recently been formed and proposes to prepare popular lectures for the dissemination of information on Illuminating Engineering and Lighting Practice.

Besides this, there are a considerable number of activities carried on, but the foregoing will be sufficient to give an idea of the work of the Society.

The Illuminating Engineering Society has already established co-operative relations with about twenty other societies. This co-operation has been undertaken in different ways and with different degrees of intimacy, depending upon the nature of the society involved. As a member of both the Association of Railway Electrical Engineers and the Illuminating Engineering Society, I feel a very considerable interest in the welfare of both organizations, and believe that if more active co-operation can be established between them, both will derive a very considerable benefit. I am aware that the Association of Railway Electrical Engineers is a leader in the subject of car lighting practice, and in this field will probably contribute more than they can hope to receive from the Illuminating Engineering Society. However, car lighting often reflects practice established in other classes of lighting, so that even here the Association of Railway Electrical Engineers may be the gainers by co-operation.

A short time ago one of the most active members of the Association of Railway Electrical Engineers remarked to me that the Railway Electrical Engineers had to deal with almost every kind of lighting problem under the sun, and I feel sure that the members of this organization will find it necessary to give more attention in the future to the problems of general lighting than in the past, and in the handling of these problems the experience of the Illuminating Engineer will be of great benefit. It is obvious that the lighting of railway restaurants, offices, shops and yards must coincide closely with the practice of general illuminating engineering of corresponding classes. The lighting of station waiting rooms is not unrelated to the lighting of other public and semi-public buildings.

Now, assuming that we are agreed that such co-operation is destined to benefit both organizations, the next question is, along what practical lines can it be effected? We can, perhaps, discuss this better by reviewing briefly the methods of co-operation which have already been undertaken by other societies. These include:

A. Joint meetings (locally) or joint sessions at conventions.

B. The representation of one society in papers presented at conventions or meetings of another.

C. The establishment of a joint committee on co-operation, perhaps supplemented by joint committees for particular purposes.

D. The representation of one society upon committees of another.

A—Joint Meetings.

At the convention of the American Institute of Electrical Engineers held in Boston in the summer of 1912, one session was placed in charge of the Illuminating Engineering Society, which supplied speakers on Illumination. The session was an exceedingly successful one, and the material presented appears in the transactions of both societies.

B. F. Fisher, J. Andreucetti and G. L. Walters.

P. Kennedy and J. L. Watson. of the Consolidated.

Doane, Andreucetti, Schepmoes and Presby on the Board Walk.

During the past season the New York Section of the Illuminating Engineering Society has held joint meetings with the New York Section of the National Electric Light Association, the Arts & Trades Club, the Municipal Art Society, the National Commercial Gas Association (New York Section), the American Society of Mechanical Engineers (New York Section), the American Museum of Safety, the New York Association for the Blind (Committee on the Prevention of Blindness). Various other Sections of the Society have also held joint meetings.

Joint sessions are to be held at the coming convention of the American Gas Institute and also at the International Congress on School Hygiene. Other similar activities are planned and it would seem to be entirely practicable to hold joint meetings with the Association of Railway Electrical Engineers in Chicago and perhaps elsewhere.

B—Interchange of Papers.

At the 1912 convention of the Illuminating Engineering Society, the Association of Iron and Steel Electrical Engineers were represented by a paper presented by their Committee on Illumination, which was quite an addition to the program. I believe it would be entirely practicable for a similar interchange of papers to be made with the Association of Railway Electrical Engineers at the coming convention.

C—Joint Committees.

The Illuminating Engineering Society is to be represented in the International Electrical Congress by a

committee appointed in co-operation with the American Institute of Electrical Engineers. The society has in the past been in active co-operation especially with regard to standardization committees.

D—Representation of Committees.

It would seem feasible for the Illuminating Engineering Society to be represented officially on the Committee on Illumination of the Association of Railway Electrical Engineers (I believe that at least six of the eight members of the present committee are already members of the Illuminating Engineering Society). On the other hand, I see no reason why the Association of Railway Electrical Engineers should not be represented on committees of the Illuminating Engineering Society, and, while I have not been officially authorized to make this statement, I feel confident that such a suggestion will be acceptable and welcome to the Illuminating Engineering Society.

The following is the one suggestion which I believe will do most to further the plans for co-operation: That the matter be placed in the hands of a joint committee appointed by these two societies, and that this committee be requested to prepare a report recommending action to the end of securing such helpful co-operation.

In discussing the committee report, Mr. J. L. Minick said that there was a tendency on the part of the illuminating engineers to disregard somewhat, the practical side of the illumination problems which are presented to the railroad men. As an illustration of this point, he said that there seems to be a considerable amount of agitation, suggesting indirect lighting for railroad cars. He stated that they found it very difficult to maintain car lighting batteries under present conditions, even where the current consumption is low. He took for example a dining car of 30-volt equipment, having a maximum current of about 45 amperes; to light that car with indirect lighting, giving the same intensity of light, he said, would require three times the amount of current. But if instead of maintaining the same intensity of illumination, we go to the same degree of brilliancy in the car, it is going to require about five times the amount of current now consumed. He pointed out that there must be some kind of a compromise between the ideal, as represented by the Illuminating Engineering Society, and the practical, as represented by the Association of Railway Electrical Engineers. A proper kind of co-operation between the two societies would undoubtedly bring this about.

Meeting adjourned.

Some of the Exhibits of Interest to Electrical Men

The American Pulley Company, of Philadelphia, exhibited their pressed steel axle pulleys for electric car lighting in both flange and flangeless types with both cast iron and steel punchings for tapered axles. They also showed pressed steel wheels for inspection and hand cars, pressed steel split pulleys for line shafting and pressed steel whole pulleys for motors and generators. Mr. Morris W. Rudderow represented the company at the convention.

The Buda Company, Chicago, exhibited electric shop trucks and the new Buda-Ross electric headlight. The company was represented by Mr. Mark A. Ross, H. P. Bailey, W. Krause, T. H. Wheeler and N. C. Study.

Commercial Acetylene Railway Light & Signal Company, N. Y., exhibited flashing signal equipment for railway signals, acetylene headlights and a new type of acetylene car lighting equipment. This latter is of special interest to car lighting men as it will form an excellent auxiliary for electric lighting equipment on postal cars or in other service where heavy duty and long hours on the side track are imposed. The burner mixes the gas so as to burn with a blue flame which heats a special mantle. The company states that this burner consumes but —— cubic feet of gas per hour. The company was represented by Messrs. C. E. Lee, D. Ahldin, O. F. Ostby, E. T. Sawyer, H. G. Doran, C. A. McCune and R. J. Faure.

Cooper Hewitt Electric Co., Hoboken, N. J., exhibited the standard long-tube Cooper Hewitt lamp, the new quartz lamp and the Cooper Hewitt rectifier for operating d. c. lamps. Represented by Mr. F. M. Haviland and Mr. M. S. Buckman, Jr.

Edison Storage Battery Company, of Orange, N. J., exhibited storage batteries for railway car lighting, railway signal batteries and batteries for telephone train dispatching, ignition and stationary lighting, as well as those employed in industrial and baggage trucks. In the center of the booth was a large illuminated battery about 7 ft. high, as shown in the illustration. A sheet of metal 1-100 in. thick, containing 250 layers of alternate copper and nickel, was exhibited. When this is cut up into tiny squares and the copper dissolved out with acid, it leaves a mass of metal flakes about 1/25,000 in. in thickness. This flake is employed as the conducting medium between the layers of active material in the positive tube. This company was represented by Messrs. R. A. Bachman, W. G. Bee, H. G. Thompson, F. V. McGinness, C. A. Luckey and O. Hildebrandt.

Booth of the Edison Storage Battery Co.

Electric Controller & Mfg. Co., Cleveland, exhibited a lifting magnet in operation, automatic motor starters, automatic controllers and a reversing planer drive employing the Reliance reversing motor. This company was represented by Messrs. R. G. Widdows, E. C. Ryan and W. C. Jackson.

Electric Storage Battery Company, of Philadelphia, exhibited various types of storage battery cells for car

lighting, signal, vehicle and automobile self-starting service. They also showed a complete line of accessories and parts illustrating the manufacture of different types of cells. The company was represented by Messrs. Charles Blizard, E. L. Reynolds, F. L. Kellogg, J. L. Woodbridge, F. G. Beetem and H. E. Hunt.

Elwell-Parker Electric Company, of New York, exhibited their drop frame type electric storage battery baggage truck; freight car type electric storage battery truck; industrial type electric storage battery truck. Represented by Mr. Lucian C. Brown and Mr. George W. Brown.

Eveland Engineering & Manufacturing Company, Philadelphia, exhibited Eveland electric riveters consisting of one motor driven electric riveter and one small bench electric riveter. Represented by Messrs. S. S. Eveland, H. F. Martin, Howard Engard, Frank Nunn and E. C. Hawley.

General Electric Company, Schenectady, N. Y., had an exhibit at Mississippi Avenue one of the new electric locomotives for 2,400-volt operation on the Butte, Anaconda and Pacific Railway, as described in our last issue. In their exhibit space on the Pier, this company showed a turbo-generator train lighting set which was driven by compressed air passing through the turbine instead of steam, and a section of the turbine casing was cut away and a plate of glass inserted so that the operation of the vanes might be observed. They also showed a new special railway oscillating car fan which has been espe-

A View in Booth of the General Electric Co.

cially designed for railroad service; reversing planer drive equipment; car wheel lathe control; five types of motors and three types of steam, air and water flow meters; battery truck crane Type W flame arc lamp and mazda lamps and headlights for interurban railway service were also exhibited. The new arc welding outfit, which has just been placed on the market by the General Electric Company, was also shown for the first time. This is a small portable set designed for use about railroad shops. The company was represented by Messrs. C. E. Barry, R. S. Bennett, B. F. Bilsland, W. J. Clark, C. Fair, F. H. Gale, J. W. Ham, J. M. Hollister, W. O. Kellogg, C. B. Keyes, E. E. Kimball, C. D. Knight, R. E. Moore, C. C. Pierce, C. A. Raymond, Frank Rhea, J. Seede, L. W. Shugg, J. O. Weatherbie and R. E. Wooley.

Gould Coupler Company, of New York, exhibited their Gould Simplex system of electric arc lighting with a motor generator set operating at all the various speed ranges, from zero to 90 miles per hour. The new ball bearing generator was shown and the covers were removed to show brush rig and bearings. A model of the pole changing device which could be turned with a hand lever, was also shown. Their standard car lighting battery, one cell of which had part of the tray cut away so as to show the plate arrangement, was exhibited. They also exhibited malleable iron journal boxes, freight and passenger car couplers, friction draft gear; cast steel bolsters, frames and coupler yokes. The company was

Booth of Gould Coupler Co.

represented by Messrs. F. P. Huntley, Geo. G. Milne, W. F. Richards, Dr. C. W. Gould, Clarence E. Rood, Col. Jno. T. Dickinson and Geo. R. Berger.

Greenlaw Manufacturing Company, Boston, exhibited their flexible metallic ball joints for steam, oil or air requirements. The company was represented by Messrs. H. A. Royce and A. L. Greenlaw.

H. W. Johns-Manville Company, of New York City, exhibited their asbestos ebony board for switchboard panels, moulded and electrical materials, electrical fibre conduit, car insulations, pipe coverings and other asbestos materials. The company was represented by Messrs. F. J. Horne, J. H. Trent, R. A. Hamaker, H. G. Newman, Geo. Christenson, J. E. Meek, J. C. Younglove, G. A. Nicol and P. C. Jacobs.

Mudge & Company, of Chicago, exhibited models showing various types of car ventilating equipment manufactured by that company. They also had a large model of a novel spark arrester. The company was represented by B. W. Mudge and G. W. Bender.

Okonite Company, of New York, had an attractive little reception booth, although they exhibited but a few samples of car wire. The company was represented by Messrs. J. D. Underhill, F. J. White and W. G. Hovey.

Pyle-National Electric Headlight Company, of Chicago, exhibited their two latest types S and E electric headlights. These two headlights are an entirely new design, different from all previous types; the headlight cases are electrically welded. Models and sectional views of the turbine were also shown. The company was represented by Messrs. R. C. Vilas, Wm. Miller, C. P. McGinnis, J. E. Kilker and J. Will Johnson.

Reliance Electric & Engineering Company, of Cleveland, exhibited a direct current adjustable speed motor operated with automatic starters; alternating and direct current constant speed motors having interchangeable dimensions for the same horsepower and speed; engine

lathe individually driven with an adjustable speed motor and automatic starter, motor driven headstock lathe. This company was represented by Messrs. H. M. Hitchcock, E. A. Lewis, S. C. Potter, D. G. Darling and A. W. Ray.

Safety Car Heating and Lighting Company, of New York, exhibited a complete assortment of car lighting fixtures both electric and gas, for both passenger cars, baggage and postal cars. The various types are fairly well shown in the accompanying illustration, but we would call attention particularly to the new postal car units, the new indirect lighting bowl shown in the center group. A novel combination fan and lighting fixture was also shown for the first time. This consists of a small fan mounted vertically above a standard lighting unit. The fan itself, however, is of special design to meet the conditions of car lighting service. This will be described in our August ventilating number. The standard type F axle lighting equipment operated from a motor generator set, also was shown under operating conditions. A dissembled generator, arranged so as to show the interior construction, brush rig, Hess-Bright ball

Booth of Safety Car Heating and Lighting Co.

bearings, etc., was also shown. The company was represented by Messrs. R. M. Dixon, A. C. Moore, J. S. Henry, R. C. Shaal, J. A. Dixon, G. E. Hulse, W. I. Thomson, J. H. Rodger, Wm. St. John, M. F. Elliott, L. Schepmoes, C. B. Adams, W. L. Garland and Geo. H. Chadwell.

Sprague Electric Works, of the General Electric Company, exhibited Sprague steel armored air brake hose, steel armored car heating hose with steel armored fittings; steel armored shop hose; flexible steel conduit, cable and fittings; Greenfield galvanized conduit; electric hoists; electric freight handling trucks; electric fans. Represented by Messrs. D. C. Durland, H. W. Uhl, C. J. Johnson and J. A. Clifford.

Standard Roller Bearing Company, of Philadelphia, had a large exhibit of annular roller bearings, journal roller bearings, roller bearings for motors, standard taper roller bearings, roller thrust bearings, ball thrust bearings and roller bearing car journals. Some excellent specimens of balls and races broken in laboratory tests, were shown. The company was represented by Messrs. J. G. Cooley and M. G. Sperzel.

U. S. Light & Heating Company, had an operating exhibit showing the operation of their Type S-1 panel. A generator with part of the casing cut away illustrated the operation of the rotating brush rig and pole changing device and clearly showed the interior construction of the generator, ball bearing mountings, etc. Small models of both the parallel link and the new drop frame suspension were shown. The company was represented at the con-

Booth of the U. S. Light and Heating Co.

vention by J. Allan Smith, A. H. Ackerman, Wm. P. Hawley, W. L. Bliss, Wm. G. Davis, R. S. Bryan, John A. White, C. C. Bradford, L. N. Talkes, W. F. Bauer and W. A. Turbayne.

Westinghouse Electric and Manufacturing Company, did not have an exhibit of material, but held forth in a beautifully decorated reception booth in the main building. This booth was very popular in the evening as well as during the day time. The company was represented

Booth of the Westinghouse Co.

by Messrs. J. C. McQuiston, H. W. Beaumont, H. C. Mode, E. M. Wise, W. H. Patterson, R. F. Moon and R. E. S. Geare.

Westinghouse Lamp Company occupied the large reception booth with the Westinghouse Electric and Manufacturing Company and were represented at the convention by Messrs. A. C. Wade, B. Hayllar, Jr., and B. F. Fisher, Jr.

The Railway Utility Company, of Chicago, exhibited both the standard utility round ventilator and the new

honeycomb types of exhaust ventilators. Both of these have been giving excellent service during the past year, both in the way of maximum exhausting capacity and complete prevention of reverse drafts carrying snow, rain or dust, whether the car is at rest or on the road. The company also showed their thermometer control for steam heat valves, hot water heating systems controlled by the same thermometer contact principle. The Utility steam hose coupler described in our issue of June, 1912, was exhibited and interesting results of a comparative test of this coupler with that of a standard make were shown. The latter was practically destroyed by kinking in coupling and uncoupling, while the Utility coupler, which had been in service on the same train the same length of time, showed practically no wear either in hose or gaskets. The company was represented by Messrs. J. P. Gallagher, Lee P. Hynes, Wm. J. Pine, E. J. Magerstat and James Denton.

Report of the Committee on Train Lighting of M. C. B. Assn.

In pursuance of instructions given your committee, a Circular of Inquiry was issued to the various railroads, covering the following points:

1. Standard design of straight axles for use in application of axle dynamos.
2. Standard design of axle-dynamo suspension.
3. Standard design for battery boxes and suspension of same.
4. Recommended practice as to maintenance and repair of batteries.

Replies were received from thirty roads, which replies were gone over by the committee, and we desire to make the following suggestions for recommended practice:

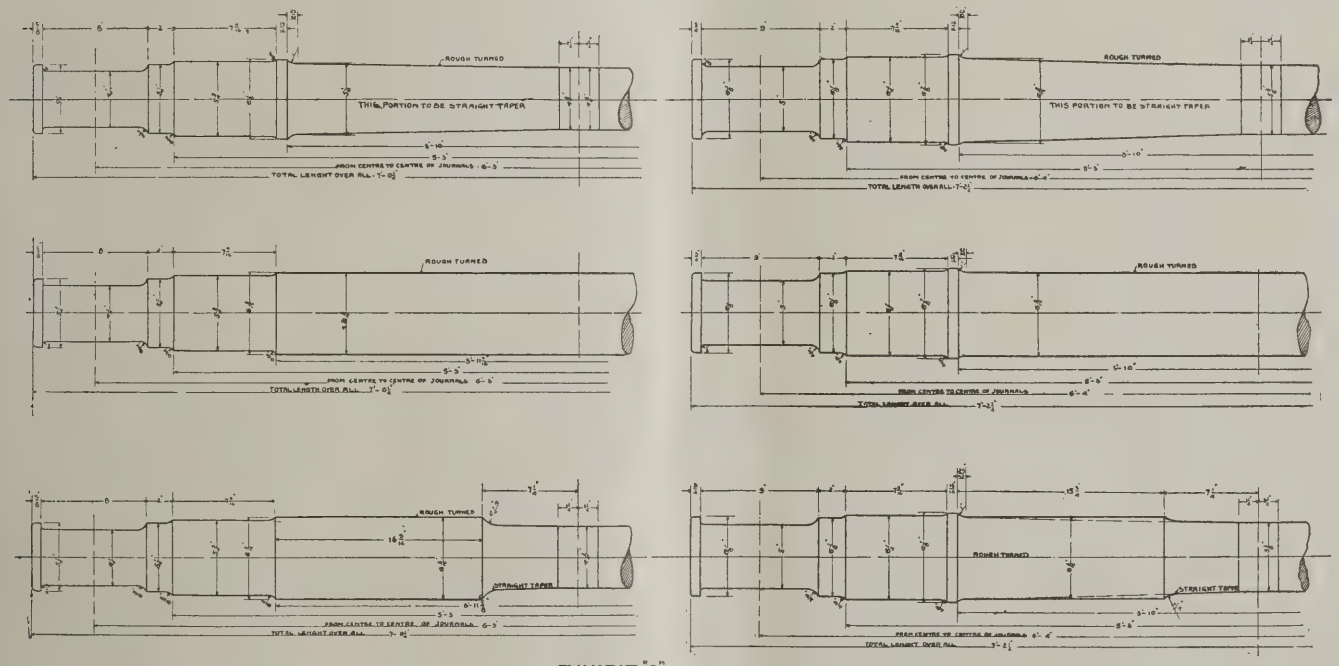


EXHIBIT "A"

Axles for Axle Dynamos

1. Axles for application of axle pulleys should be in accordance with dimensions shown on Exhibit "A."

NOTE.—Your committee feels that the question of design of axles should be left to the mechanical men of the individual railroads in question.

You will note that on Exhibit "A" is shown three designs: First, axle in accordance with M. C. B. standard, rough-turned; second, axle straight between the wheel-fit collars, rough-turned; and third, axle with straight pulley fit.

In any of the above designs the axle pulley as recommended in paragraph 18 of recommended practice can be applied with the proper bushing.

Standard Design of Axle-Dynamo Suspension

2. Axle-dynamo suspensions must be designed so that with full diameter wheels and truck on straight, level track, any part of the dynamo or suspension must have a clearance not less than 6 inches above top of rail, and a clearance of at least 3½ inches between any part of the mechanism attached to the car body.

3. In axle-dynamo suspensions the metal carrying the weight of the dynamo must not be subjected to wear.

4. In axle-dynamo suspensions, if side arms are used, the end to be secured to the truck frame must extend under transom and be bolted to the side frame near the transom, and if carried through or over end sill, must be held securely to end by a hooked bolt not less than ¾ inch in diameter.

5. When possible, the belt should go over the end sill and under the brake beam with belt clearances of at least 1 inch.

6. A typical design covering the above recommendations is shown on Exhibit "B," and recommended where applicable.

NOTE.—On account of the variety of trucks and car designs, it is impossible for your committee to recommend a standard suspension which will meet all conditions; the committee, therefore, recommends the design shown on Exhibit "B" where applicable, and in addition have inserted the general requirements in paragraphs 2, 3, 4 and 5, which, if adhered to, will

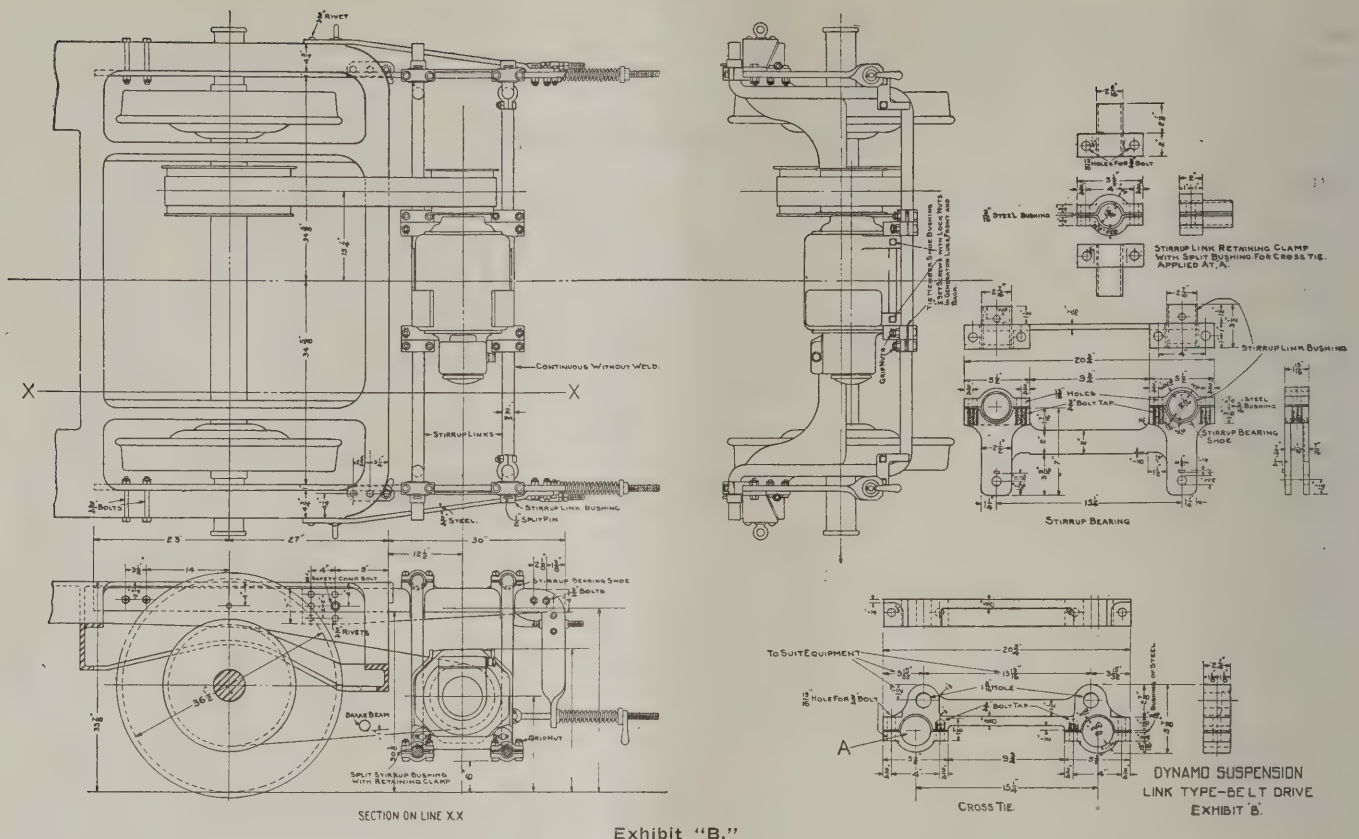


Exhibit "B."

eliminate the most objectionable features of suspension now in use.

Standard Design of Battery Box

7. The inside dimension of battery boxes should be as follows:

Depth, front to back, 2 feet 4 inches.

Height in clear, not less than 21½ inches.

Length of compartment for two standard double-compartment tanks or equivalent, 22⅝ inches.

Length of compartment for four standard double-compartment tanks or equivalent, 3 feet 9¼ inches.

8. Battery boxes with two compartments each 22⅝ inches long, or with one compartment 3 feet 9¼ inches, must be designed to safely carry a battery weight of 1,600 pounds. Battery boxes with four compartments each 22⅝ inches long, or two compartments each 3 feet 9¼ inches long, must be designed to safely carry a battery weight of 3,200 pounds.

9. That in all battery-box designs, two angle irons or straps shall extend longitudinally under the battery box in such a location that in case of a defective battery-box the battery trays will be supported by the said angle irons or straps; the angle irons or straps shall be supported to the car body independent of the battery box proper and shall be of sufficient strength in all parts to safely support the battery in accordance with the weight shown in paragraph 8 and the additional weight of the battery box proper, and the angle irons or straps and the supports for same shall be so installed that they can be readily inspected for corrosion.

NOTE.—On account of design of car underframing and the requirements of a different service, your committee finds it impossible to make detail specifications and dimensions for battery boxes which would be applicable for all conditions, and have therefore outlined general specifications as covered in paragraphs 7, 8 and 9, which will provide for proper strength of battery boxes and proper dimensions to allow of interchangeable equipment.

In the above you will note that on the height of battery box the minimum dimension is given instead of an exact dimension, as your committee felt that the maximum height of box obtainable should be used, but that the 21½-inch has been found to be the mixi-mum height that can be applied on a number of roads on account of road clearances.

Recommended Practice as to Maintenance and Repairs of Batteries

10. The following repair instructions were forwarded to the Secretary, Mr. Joseph W. Taylor, to be referred to the Arbitration Committee for insertion in the Code of Rules:

"For repairs to electric lighting equipment on cars in interchange or leased cars, the instructions issued by the manufacturers of the apparatus should be strictly adhered to. In the absence of any agreement, the material furnished and applied must be of the manufacturer's make."

In the above the committee recommend that paragraphs 1, 2, 3, 4, 5 and 6, if approved as recommended practices, follow paragraph 19 in the present train lighting recommended practices under the caption of axle-dynamo suspension. Paragraphs 7, 8 and 9, following paragraph 17 of train lighting recommended practices, under the caption of battery boxes.

In addition to the above, the committee beg to make the following recommendations:

11. Under the caption of axle dynamo, the following should be added to paragraph 18:

"Diameter of axle pulleys should preferably be 17 inches or 21 inches; the diameter of generator pulley should preferably be 8 inches or 11 inches."

12. M. C. B. Standard Sheet No.-6 should be revised to show overall dimension across the end of tank 10 inches.

13. Under the caption "Axle Dynamo," following paragraph 19, should be added the following:

"The electric connector between the dynamo leads and permanent wiring on the car should be made with non-reversing self-locking receptacle and plug."

T. R. Cook, *Chairman.*
C. A. Brandt,
Ward Barnum,
D. J. Cartwright,
E. W. Jansen,
J. H. Davis,
C. H. Quinn, *Committee.*

THOSE WHO REGISTERED.

Active Members.

J. A. Andremetti, Gen. Fmn. C. & N. W. Ry.
J. H. Davis, Elec. Engr. B. & O.
L. S. Billasi, B. & O.
H. C. Meloy, Ch. Elec., Lake Shore.
E. W. Jansen, Elec. Engr., Ill. Central.
J. R. Sloan, Engr. Car Stg., P. R. R.
J. L. Minick, Chief Draftsman, P. R. R.
E. E. Goddard, Asst. Engr. Car Ltg., P. R. R.
N. C. Opel, P. R. R.
J. M. Craig P. R. R.
D. G. Thwaites, P. R. R.
J. C. Snyder, P. R. R.
J. B. McIntosh, Supt. Wash. Term. Co.
R. R. Spaulding, Lehigh Valley.
J. M. Brown, Lehigh Valley.
H. M. Warren, Elec. Engr., D. L. & W.
C. D. Axtell, D. L. & W.
A. S. Bieseckn, D. L. & W.
E. J. Powell, D. L. & W.
H. A. Stofflet, Philadelphia & Reading.
A. McGary, Ch. Elec., N. Y. Central.
L. B. Knight, B. & A.
C. W. Dodge, B. & A.
Frank Zimkowski, Elec. Fmn., N. Y., N. H. & H.
G. T. Vaughn.
C. H. Quinn, Mech. Engr., Norfolk & Western.
G. Garner, Elec. Engr., Mo. Pac.

Associate Members.

G. L. Walters, The Adams & Westlake Co.
E. L. Langworthy, The Adams & Westlake Co.
Dan Woodhead, Central Electric Co.
Patrick Kennedy, Consol. Ry. El. Lt. & Equip. Co.
T. L. Mount, Consol. Ry. El. Lt. & Equip. Co.
E. G. Smith, Crouse-Hinds Co.
C. H. Bissell, Crouse-Hinds Co.
Geo. W. Cravens, C. & C. Elec. Mfg. Co.
H. G. Thompson, Edison Storage Battery Co.
C. A. Luckey, Edison Storage Battery Co.
O. R. Hildebrant, Edison Storage Battery Co.
H. E. Hunt, Electric Storage Battery Co.
F. G. Beetem, Electric Storage Battery Co.
O. H. Caldwell, *Electrical World.*
G. H. Stickney, General Electric Co.
J. O. Wetherbee, General Electric Co.
A. L. Broe, General Electric Co.
R. E. Simpson, General Electric Co.
B. A. Bilsland, General Electric Co.
R. E. Simpson, General Electric Co.
Geo. G. Milne, Gould Coupler Co.
Geo. R. Berger, Gould Coupler Co.
W. L. Batt, Hess-Bright Mfg. Co.
L. C. Doane, Holophane Works.
R. S. Carrick, Independent Lamp & Wire.
P. C. Jacobs, H. W. Johns-Manville.
Maj. Azel Ames, Kerite Ins. Wire & Cable Co.
B. L. Winchell, Jr., Kerite Ins. Wire & Cable Co.
J. W. Young, Kerite Ins. Wire & Cable Co.
P. W. Miller, Kerite Ins. Wire & Cable Co.
Jos. A. Renton, Kerite Ins. Wire & Cable Co.
W. E. Fawcett, Main Belting Co.
N. G. Stark, Oneida Steel Pulley Co.
F. J. White, Okonite Co.
Robert E. Thayer, *Railway Age-Gazette.*
Edward Wray, *Railway Electrical Engineer.*
A. C. Moore, Safety Car Htg. & Lt. Co.
L. Skepmoes, Safety Car Htg. & Lt. Co.
Geo. E. Hulse, Safety Car Htg. & Lt. Co.
W. L. Garland, Safety Car Htg. & Lt. Co.
J. L. Marsh, Safety Car Htg. & Lt. Co.
M. B. Chase, Sangamo Electric Co.
W. P. Hawley, U. S. Lt. & Htg. Co.
Wm. A. Turbayne, U. S. Lt. & Htg. Co.
Alex. Russell, U. S. Lt. & Htg. Co.
B. F. Fisher, Westinghouse Lamp Co.
W. E. Ballantine, Willard Storage Battery Co.
F. S. Gassoway, Willard Storage Battery Co.

The Flame Carbon Arc Lamp

Mr. W. A. Darrah at the recent meeting of the New England section of I. E. S. gave a very interesting talk on this subject. Inasmuch as long burning flaming arc lamps are being extensively employed in railroad station and yard lighting, some of the points brought out by Mr. Darrah will be of interest to our readers. He said that the type of carbon used marks one of the great differences between the present flame carbon arc lamps and the old solid carbon arc lamps.

The flame carbon differs from the solid carbon in that certain chemicals are added during their manufacture with the object of increasing the light; securing better operation, and reducing slag troubles. The chemicals commonly added may be classified as follows:

(1) **Illuminants.**—These comprise the compounds of three or four peculiar elements. For white light, cerium and titanium offer the greatest possibilities; while calcium and, to some extent, tungsten form the main illuminants in yellow light carbons.

(2) **Sustainers.**—Since the flame carbon arc, as illustrated in Figs. 2, 3 and 4 is very considerably longer than the enclosed carbon are, it would be prohibitively unstable unless certain compounds were added to remedy this defect. At present, fluorides and to a small extent, borates, form the most suitable sustainers when slag troubles, evaporation point and cost are considered. These elements are frequently introduced as compounds of the illuminants.

(3) **Conductors.**—In order to overcome certain troubles which arise due to slag which may form in case the carbon is consumed more rapidly than the illuminants and sustainers, certain compounds are frequently added to prevent slag troubles which might otherwise result.

Fig. 10a shows the variation of candle-power which occurs with increased voltage on a 10-ampere, alternating current flame carbon, arc between various varieties of carbon. These curves are interesting as indicating that, with few exceptions, the candle-power increases directly with the voltage until a certain value is reached, and in some cases somewhat more rapidly. This is to be expected, as the increased voltage allows an increased arc length and therefore a longer flame. When a certain value of voltage and a certain arc length has been exceeded, additional cooling effects introduced prevent a material increase in the total light flux emitted, and for this reason, the curve flattens out after passing a certain critical point.

Fig. 11 shows the effect of increased currents on a 48-volt, 60-cycle arc under normal conditions. It will

be noted that the light emitted increases uniformly with the current over the majority of the range given. In this connection, it is interesting to note that the addition of illuminants to a flame carbon does not increase the total light emitted in a direct ratio to the amount of illuminants added. In other words, as the percentage of cerium oxid in a white-light carbon is increased, the candle-power first increases until a maximum value is reached, after which the addition of more cerium oxid will decrease the intensity of the light emitted for a given amount of electrical energy. This condition together with the effect of slag, which may be very serious in improperly designed carbons, limits the amount of mineral material which may be added to the carbons.

The difficulties introduced by slagging of the flame carbons have received considerable attention and have been overcome commercially. Assuming that these carbons are properly designed, the outage during normal, commercial operating conditions should not exceed ½ to ¾ of 1 per cent., provided the lamps are maintained in the proper condition.

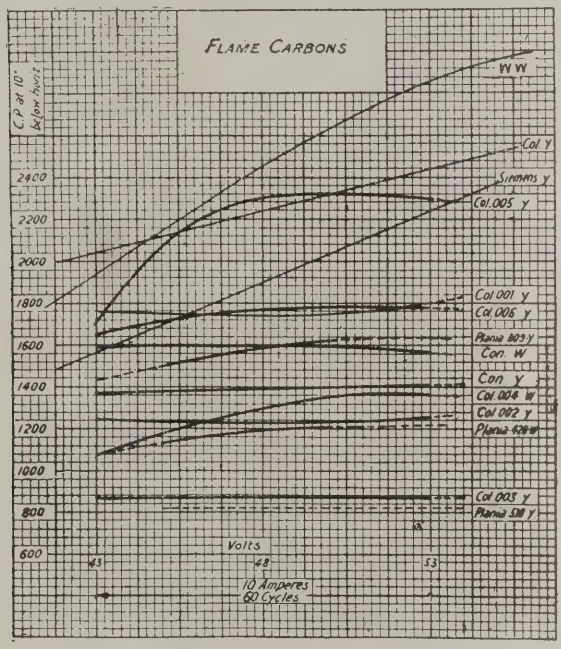


Fig. 1. Variation of Candle Power with Increase of Voltage Across the Arc of Flame Carbons.

Slagging may be caused by the entrance of air into the arc chamber, due to imperfect globe seats or leaking condensers. The excess of air causes the consumption of the carbons to proceed more rapidly than the mineral components can be vaporized. This allows an accumulation of fused oxids and fluorids upon the surfaces of the electrodes, thus forming when cold, an insulating layer. An excessively low current or an arc longer than normal may also cause slagging.

None of the difficulties mentioned above should be encountered in the commercial lamps providing proper globes are used and the lamps are maintained in good condition. A very small amount of slag is no detriment to the operation of the flame carbon lamp since the hammer blow which is given when the carbons fall together prevents trouble of this nature from being serious.

From a mechanical standpoint, it may be stated that the carbons now commercially obtainable are entirely satisfactory. Present diameters vary from approximately ¾ in. to ⅞ in., depending upon the conditions under which they are used. It is possible to secure these carbons within 0.025 in. from the specified diameter without adding appreciably to their cost. Since this is true, it will be evident that a ring clutch may be employed in the operation of flame carbon lamps with entire satisfaction.

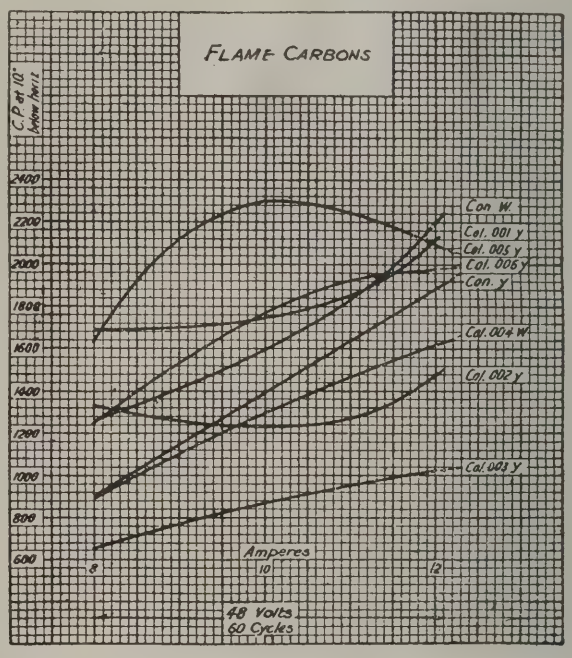


Fig. 2. Variation of Candle Power with Increase of Current of Flame Carbon Arc.

Since the average flame carbon contains more than 30 per cent. of solid material which is not consumed, but which must be vaporized by the arc, the problem of disposing of this material naturally required solution. It was found that this solid material (called "soot" by lamp operators) would not condense upon surfaces which were maintained at an elevated temperature, while it will readily condense in the form of a soft white powder upon any cool or relatively

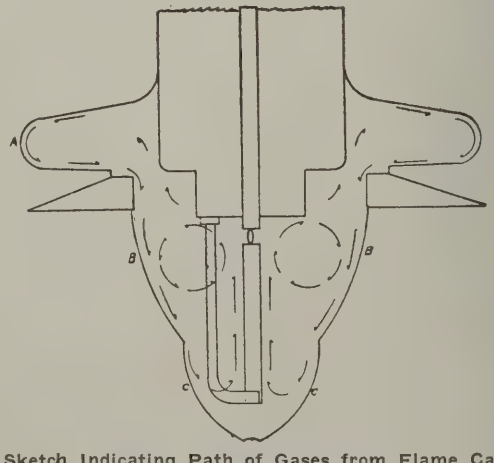


Fig. 3. Sketch Indicating Path of Gases from Flame Carbon Arc in One Type of Lamp.

cool surface. This is taken advantage of by so arranging the globes of the lamps that they will be materially hotter than a second and communicating chamber into which the gases from the arc are forced.

Since the temperature of the arc in its cooler portions probably exceeds 2,500 deg. C., while the remainder of the arc chamber is filled with gas at a tem-

perature not exceeding 150 deg., it is obvious that the different density of the two gases is sufficient to account for the violent motion in the vicinity of the arc.

The life of a flame carbon depends upon its density, the current, the length of the arc, the composition, and above all, the tightness of the enclosure in which the carbon is consumed. Every effort should be made to maintain the enclosure as perfect as possible at all times. Only accurately ground globes, free from flaws at the globe seat, should be used; while the portion of the lamp which comes in contact with the globe should be made from a hard, strong alloy which will be affected as little as possible by the fumes from the arc. To insure maximum life, it is necessary that all joints in the condensing chamber be maintained tight and that the condenser be removed as little as possible. Under commercial conditions, a life of from 15 to 20 hours per inch may be obtained from standard carbons.

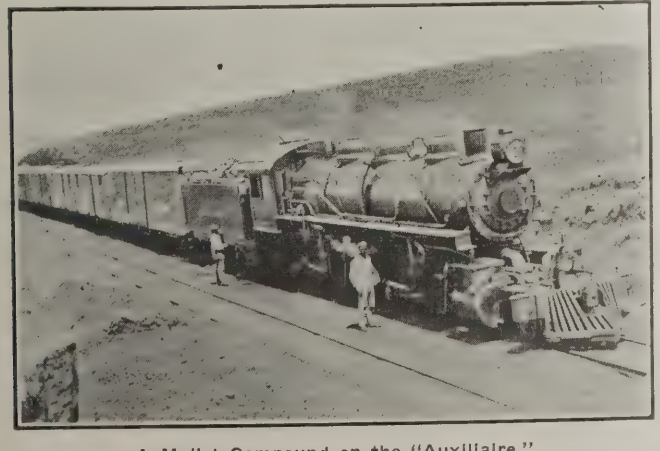
Brazil and Its Transportation Problems

A. I. TOTTEN
Superintendent of Motive Power of the Brazil Railways

The South American continent, and especially the country of Brazil, represents an almost unknown factor to the average inhabitant of the United States, although it is a part of our own hemisphere.

Where the Railroad Does Not Reach.

The papers are filled with news of Europe and Asia and, from the writings of the various explorers, we obtain a fairly comprehensive idea of Africa. We look upon South America as a torrid, equatorial country; having enormous forests inhabited by wild animals and equally wild Indians; but this is only true of the extreme Northern parts, bordering on the Amazon River.



A Mallet Compound on the "Auxiliaire."

What might truly be termed the populous section of the country is along the Atlantic seaboard and inland for a distance of possibly one hundred miles. In this territory we find Pernambuco, Bahia, Rio de Janeiro, Sao Paulo, Santos and various other less important cities and towns. The cities of Rio de Janeiro and Sao Paulo are the principal ones as regards population, but Santos must be given prominence as an important commercial center, where probably 80 per cent of the world's coffee supply is exported and enormous quantities of goods are imported for a large portion of this country.

All of the important cities, mentioned above, have first class street car lines, electric lights, gas plants, etc., now considered necessary for a civilized community, and a large number of other smaller places have equally as good facilities.

One Solution for Transportation.

The newcomer to this country is immediately impressed with the enormous duties exacted by the government for all imported goods and, due to the fact that the manufacturing industries here are extremely small, nearly all manufactured articles are imported. This serves as a protection to the native industries, with the result that goods of native manufacture are maintained at substantially the same prices as the imported articles. As an example, the delivery of copper wire in Sao Paulo means a cost of 98 cents per kilogram, which is equivalent to about 45 cents per pound, as against 20 cents per pound in the States. Structural steel, pipe, and in fact everything necessary to the development of the country bears the same proportionately heavy duties; thus it is evident that the cost of living is extremely high and will continue so

unless the government finds a more rational way to secure finances for running the nation.

Another thing, which mitigates against rapid development, is the cost of fuel. Up to the present time no suitable coal for steam production has been discovered and it is therefore necessary to import coal from Wales at a cost, delivered, varying from $15.00 to $20.00 per ton. In a great many cases wood is substituted for coal as fuel for the railroads and manufacturing establishments, but the cost of wood, averaging about $1.33 per cubic meter, represents about three-fourths as much as the cost of coal, when considering the relative heating values. In the state of Minas Geraes there are large quantities of iron ore, which is shipped abroad in the crude state due to the high cost of fuel which would be necessary for its reduction.

As an offset to the high cost of fuel, however, this country is blessed with an enormous quantity of water power, which is being rapidly developed. The electric energy, necessary for the city of Sao Paulo, is supplied in this manner and the Sao Paulo Electric Co.

Passenger Train on a 24-In. Gauge Railroad.

is, at present, constructing a power plant with a total capacity of 45,000 horsepower and a transmission line approximately 100 miles long to take care of additional power requirements. The current output from this plant will be transmitted at a potential of 85,000 volts and a frequency of 60 cycles.

It might be mentioned that nearly all of the important enterprises here are conducted by foreigners with foreign capital. The English interests probably predominate with German second. In a number of cases where industrial plants and railroads are owned by Brazilians they are operated by Englishmen.

The railroads are confined almost entirely to the region adjacent to the Atlantic coast and inland for a distance of from four hundred to five hundred miles. They are, for the most part, owned by the government and, when leased to outside parties, the government continues to control their operation through the medium of fiscal agents for the various lines in a much more drastic manner than the railroads of the United States are controlled by the government.

One thing, which will tend to prevent satisfactory progress, in the transportation problem, is the fact that no standard gauge for railroads has as yet been effected. The Brazil Railway operates approximately 5,300 kilometers of railroad having a meter gauge, that is 3 feet 3⅜ inches. The Sao Paulo Railway, between Santos and Jundiahy, with a total length of about 125 kilometers, has a 5 ft. 3 in. gauge, and this same gauge is also used by the Central Railroad, operated by the government, whose principal line runs from Rio de Janeiro to Sao Paulo. The balance of the more important lines in the country use this same gauge, but some of the minor roads have gauges as narrow as 24 ins.

The Brazil Railway conducts what is undoubtedly the most important transportation system in Brazil Its lines extend from Sao Paulo on the north to the frontier of Uruguay on the south, with four separate connections to the seaport, namely, at Paranagua, Sao Francisco, Porto Alegre and Rio Grande. On its tracks are seen equipments manufactured according to the

A View of the Sorocaba Engine House.

accepted American standards. Numerous Mallet compound engines, designed for meter gauge, pull the heavy freight trains, consisting principally of cars constructed according to the Master Car Builders' specifications, but equipped with vacuum brakes instead of Westinghouse air brakes.

Differing, however, from American practice, all wheels are steel tired. This refers to freight cars as well as other equipment. There are two reasons which call for the necessity of thus equipping the rolling stock: First, the numerous curves on all of the lines, exceeding in number and degrees of curvature anything found in the United States; and second, the absence of facilities for making disposition of scrap iron or other refuse material in this country. In the United States a fair return is received for car wheels which have outworn their usefulness, thus reducing the unit cost for service to an extremely low figure.

A German-Made Locomotive on One of the Lines.

The passenger, sleeping, dining and baggage cars are, for the most part, equipped with electric lights, using an English made axle system, which gives most excellent results. In some instances the second-class coaches are not equipped with generating apparatus, but they receive current for lighting from first-class cars or other second-class cars, so equipped, through a jumper connection. A more detailed description of the apparatus used will be furnished in another article.

The principal repair shops are located at Mayrink, Sorocaba, Curitypba, Rio Grande and Santa Maria

These are being electrically equipped and will, in the majority of instances, have individual motor drive for the various machines. In nearly all cases current will be purchased, thus avoiding the necessity for making power plant installations. A description of the shop at Mayrink will be given in another article.

The shops now in operation and those projected are fairly representative of moderate size repair shops in the United States. The longitudinal plan for erecting shop is being followed in preference to the transverse arrangement. This gives the advantage of providing

A Gasoline Inspection Car, Mr. Totten Is Seated in the Car.

two cranes of moderate size for handling locomotives and material, instead of one large crane.

Some especial mention should be made of the Sao Paulo Railway, which starts at the seaport city of Santos and operates, as above indicated, to Jundiahy via Sao Paulo. The great majority of coffee, for export, is shipped over this road from Jundiahy to Sao Paulo, and between Sao Paulo and Santos this road represents the only connection, hence handles enormous quantities of freight and passengers. It will be noted, by referring to the map, that a chain of mountains runs parallel to the eastern coast of Brazil for the greater part of its length. All railroad connections from the coast to the interior must cross these mountains, which are distant from the coast about twenty kilometers. The Sao Paulo Railway crosses by the means of cables, divided into five sections, and which are gripped by special locomotives attached to the trains at the foot and top of the mountain. The trains are divided into four car sections and the operation is controlled in such a manner that one section goes down as the other section comes up, thus equalizing to a great extent the load on the stationary engine, which operates each length of the cable.

The Sao Paulo Railway may truly be termed "The Nickel Plate Line." A certain proportion of all profits, in excess of twelve per cent, must revert to the government, according to special terms contained in their lease. In consideration of this fact the railroad, which would certainly earn much more than this interest for its stockholders, invests large sums on its road bed and rolling stock, with the result that it excels in perfection in many ways almost any railroad in the world. The engines are finished with brass trimmings and truly represent a handsome piece of equipment. Electric block signals protect the trains and the alignment of the tracks leaves nothing to be desired. To the best of my knowledge they have never had an accident.

A number of the other railroads are returning handsome profits to their stockholders, but the success or failure of some of the transportation systems depends entirely upon the rapidity with which the sections of the country, through which they operate, build up. This condition is practically paralleled by the railroads operating through the southern section of the United States.

Illumination of Passenger Cars*

By J. L. MINICK

Chief Draftsman Pennsylvania Railroad.

The story of the railroad had its beginning nearly three hundred years ago with the construction of a wooden track at New Castle-on-Tyne, England, to facilitate the haulage of coal wagons by horses. The early railroads were all privately owned and operated and for two hundred years were used almost exclusively for the transportation of coal and other heavy commodities.

Many attempts were made to adapt the steam engine to railway use but it remained for George Stephenson, "the father of the modern railway system," to accomplish the feat. His "Rocket" took the premium of five hundred pounds sterling offered by the Liverpool & Manchester R. R. in 1829 for the "best locomotive tested." This railroad was probably the first to be chartered to conduct a general transportation business.

Several small horse operated railroads were constructed in America prior to 1830 and charters were also granted for several, now prominent, steam roads. The first of these to be placed in operation was the New Castle & Frenchtown R. R., on November 12, 1831, the locomotive used on that memorable day being the "John Bull," built by Stephenson, and now in the possession of the Smithsonian institute at Washington.

The State Canal System of Pennsylvania was chartered in 1826 "to connect the waters of the Delaware with the Ohio River and the Great Lakes." Rail connections, the Philadelphia & Columbia R. R., connected the Schuylkill and Susquehanna Rivers also the Juniata and Conemaugh, the Portage R. R. The Philadelphia & Columbia R. R. purchased the first locomotive of entirely American construction (the Lancaster) from Matthias Baldwin, a watchmaker and founder of the present Baldwin Locomotive Works.

Evolution of the Passenger Car.

The owners of the Liverpool & Manchester R. R. were evidently somewhat skeptical of the commercial value of the transportation of passengers. Their pas-

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senger equipment, the single car, "The Experiment," was leased to Thomas Dixon, who operated it between Stockton and Darlington for several years. This car, like many of its followers, was drawn by a single horse. Seats along the sides provided space for six or eight passengers, while a door and steps at the rear were the only means af entrance to the car.

Many of the earlier American cars were of similar design. The better class of primitive cars, however, consisted of one or more stage bodies mounted on four wheel trucks. One of the early types used by the Portage R. R. had a shingled gable roof and weather-boarded sides. It seated comfortably probably six or eight persons. Platforms and doors in the ends of the car came into use about 1835.

The Philadelphia & Columbia R. R. purchased the first car equipped with four-wheel trucks free to run independent of the car body. The "Tioga" car, built for the Tioga R. R. in 1840, was of similar, but more modern design. It was considered a model of excellence though it had neither springs, closets, toilets or water coolers. Heat was supplied in winter by a wood stove in the center of the car, and ventilation, through a ten-inch circular opening in the roof. A tallow candle at each end of the car furnished such light as was necessary.

Sleeping cars were first used by the Baltimore & Ohio R. R. In describing the first of these cars the Baltimore Chronicle of October 31, 1838, says:

"It is one of the completest things of the kind we have ever seen, and it is of beautiful construction. Night traveling on a railroad is, by the introduction of these cars, made as comfortable as that by day, and is relieved of all irksomness. * * * Nothing now seems to be wanting to make railroad traveling perfect and complete in every convenience, except the introduction of dining cars, and these, we are sure, will soon be introduced."

In contrast we have the following statement from another newspaper correspondent about twenty-five years later:

"I ran across an early sleeper somewhere in the Blue Ridge Mountains of Southwest Virginia. It was low and narrow, and dark and stuffy. It wobbled and creaked and moved in all directions like a ship's compass. * * * The lower berths were narrow and so short you had to lie in one like a half opened pocket knife, with your knees in the air and the bed clothes pushed up like a tent. You did not need to be pious to thank heaven when you got out of that car."

The next improvement in car construction came with the "clear story" or "upper deck" designed to provide sufficient additional headroom to permit placing the lamp fixture in the center of the car. It also provided a means of additional ventilation, through ventilators placed between the two decks. The upper deck has remained one of the permanent features of passenger car design and construction, although in late steel equipment it serves no useful purpose.

The modern passenger car or coach is constructed entirely of steel except for the floor, window frames and seat arms. The floor generally consists of composition and the window frames and seat arms are wood. In contrast with Thomas Dixon's Car, this has a seating capacity of eighty or more persons.

Light Sources.

In their paper before the American Society of Mechanical Engineers last winter, Messrs. Wood and Currie divided the development of passenger car lighting into four twenty-five year periods, beginning with the candle period in 1825. Oil lamps came into general use about 1850 and gas about 1875. About 1900 electricity came into use as a means of lighting passenger cars in steam train service, though it had previously been used extensively in electric cars.

Information concerning the early use of candles is very meagre. It is known, however, that Thomas Dixon, the driver of the first passenger car, furnished his patrons with candles. He also furnished a rough

Fig. 1. Center Deck Oil Fixture About 1860.

board table in the center of the car for supporting the candles. The passengers were required to light the candles and tend their feeble flames. The board table later gave way to sockets attached to the walls, and these were superseded by fixtures having glass chimneys to protect the flame and a coil spring in the bottom of the socket to force the candle upward as it burned away, thus maintaining the flame at a predetermined position. This type of candle fixture is used

Fig. 2. Pinch Gas Unit About 1880.

extensively today as an emergency lamp in case of failure of the primary gas or electric system.

"Center-lamps," with one or more candles, came into use during the latter part of the candle period. Many labor saving conveniences were developed, as for instance, an adjustable top to hold the chimney in position without the aid of thumb screws, and brackets, that permitted of shifting the position of the lamp both vertically and horizontally.

While comparatively little has been written concerning the earlier types of oil lamps it is safe to assume that they resembled the candle lamp in general design. It was comparatively inexpensive and quite convenient to remodel the candle fixture to support an oil lamp. Such changes were very desirable as it was a very difficult matter in car work to patch a hole in

the side or roof of a car without showing the patch.

Burners, wicks, etc., were adapted to the kind of oil used. The use of the heavier oils, such as rape seed and Colza vegetable oils, lead to the development of central draft burners, in which a current of air was delivered to both sides of the flame to produce more rapid combustion. The Argand, Belgian, Acme and student lamps are representative types of central draft burners. Two wicks feeding one flame was another means of securing more rapid combustion, and consequently a brighter light.

Many of the oil fixtures were equipped with telescoping attachments for lowering the lamps for cleaning and filling. Others had removable oil reservoirs. Re-

Fig. 3. Electric Fixture, 1906.

flectors came into use during the oil period. In smoking cars, baggage and mail compartments cheap metal or mirror glass disks were placed back of the lamp to throw the light out into the car. In coaches conical opal glass shades were slipped over the chimney and were supported by the fixture arms.

Coal gas was probably the first kind of gas used in lighting railway cars. It was secured from the city gas mains and stored in a canvas reservoir, reinforced by wooden hoops, in the guards van. Iron pipes, and rubber hose between the cars, served to connect the lamps to the reservoir. Gasoline mixed with air was very extensively used. Acetylene gas was also used to some extent. Pintsch gas, invented in 1867, came into very general use on account of its reliability and increased storage capacity, obtained by charging at high pressure.

A variety of burners were used, the first of which was probably the flat or "fish tail" flame. There was also a central draft oil burner. The substitution of mantles greatly improved the quality of the light. For reasons previously explained the earlier types of gas fixtures resembled the oil fixtures. Generally the fixtures, used prior to about 1905, were very ornamental in design to correspond with the interior finish of the car. The introduction of the steel car has changed this condition and present day fixtures have been greatly simplified.

While it had previously been used in electric cars, the incandescent lamp did not come into general use as a means of lighting passenger cars in steam train service until about 1900. Carbon, metallized, carbon, tantalum and tungsten filaments were all used in about the order named, the latter type being in general use today. It was the high efficiency of the tungsten lamp that made electric car lighting possible, as the demand upon the battery for current was brought within the necessary limits of battery capacity and weight.

The earlier electric fixtures were generally gas fixtures remodeled to take incandescent lamps, many of which were not equipped with reflectors. Such reflectors as were used served as dust collectors, and by thus attracting attention, served to stimulate the cleaning of the car.

The wide diffusion of knowledge of illumination, and the constant and earnest study of the problems of serving the travelling public, has resulted in better fixture designs, better distribution of light, higher intensities, and higher efficiencies. Filigree work has almost entirely disappeared. Simplicity of design has very materially decreased inital costs and the use of reflectors specially adapted to car service has made it possible to conceal the incandescent filament without the use of opal dipped or frosted lamps. It should not be assumed, however, that the last word has been said on this subject. There is a wonderful field for further development and improvement.

While close attention is now being given to the proper lighting of passenger cars, the chief effort, until within comparatively recent years, was to reduce energy consumption and simplify methods of operation. Lack of attention to the proper shielding of the filaments, the better distribution of light, and the production of intensities sufficient for the comfort of passengers, was largely due to lack of knowledge on this subject and lack of facilities for accurately determining the conditions that obtained. The development of the candle-foot photometer and other devices has made it possible to determine all of these items and wonderful improvements have been made in recent years.

The data herewith has been selected from a series of tests of oil, gas, and electrically lighted cars, conducted during the past three years. The cars were all taken from regular service and the results are therefore, representative of service conditions. While the dimensions of the cars, the spacing and height of fixtures, color of interior finish, etc., vary to a slight degree, the variations are not so great that comparison of the several types of equipment cannot be made.

No special attention was given to the cleaning of the cars other than to see that the lamps were cleaned and in proper adjustment. All tests were conducted at night and the blinds were drawn to prevent the leakage of outside light. Where air draft and temperature conditions tended to affect the value of the illuminant,

CAR		FIXTURES		ILLUMINATION		FOOT CANDLE READINGS					
Class	P.T.	System	Oil	Test	Standing	1	.64	1a	.61	1w	.54
No.	3218	Fixture	2Lt. Gen. Deck	Reading Plane	36"	2	.60	2a	.56	2w	.50
Type	Wood	No. Fixtures	4	Max. F.C.	.64	3	.64	3a	.52	2w	.42
Floor Area, Sq. Ft.	367	Spacing	124"x115½"	Min. F.C.	.24	4	.64	4a	.61	4w	.56
" FINISH		Height	95"	Aisle Av. F.C.	.55	5	.61	5a	.57	5w	.53
Upper Deck	Light Green	Reflector	Cl. Ch. #40 Dm #04	" Seats Av. F.C.	.50	6	.53	6a	.45	6w	.35
Lower "	"	Lamp	No. 3 Dual Burner	Window " "	.44	7	.41	7a	.39	7w	.35
Above Belt	" Oak	Rating		Car Av. F.C.	.31	8	.34	8a	.28	8w	.24
Below "	"	Lumens per Lamp		Lumens Utilized	114						
Seats	Red Plush	Total Lumens		Efficiency							

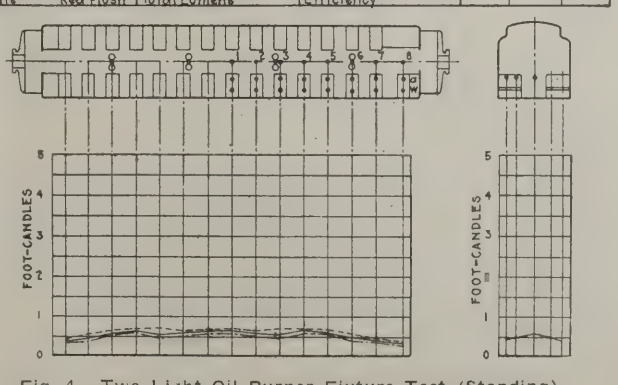

Fig. 4. Two-Light Oil Burner Fixture Test (Standing).

both standing and running tests were made. All running tests were made while the cars were running at a uniform speed of about 40 miles per hour. So far as possible, all equipment was adjusted to operate at the manufacturers rating and where such adjustment was not possible proper correction has been allowed. In the case of running tests, lamps were adjusted for running conditions and no change in adjustment was made for standing tests. Foot-candle readings were taken on the horizontal plane 36 inches above the floor.

CAR		FIXTURES		ILLUMINATION		FOOT-CANDLE READINGS							
Class	Pf	System.	Oil	Test	Running.	1	1.34	1a	1.27	1w	1.15
No.	Q V R R 3210	Fixture.	2 Lt Center deck	Reading Plane.	36"	2	1.29	2a	1.35	2w	1.20
Type	Wood	No. Fixtures	4	Maximum F.C.	1.44	3	1.11	3a	1.14	3w	1.15
Floor Area Sq. Ft	400	Spacing	126"	Minimum F.C.	.62	4	1.44	4a	1.39	4w	1.19
FINISH		Height	92"	Aisle av. F.C.	1.11	5	1.29	5a	1.25	5w	1.02
Upper Deck	Olive Green	Reflector	Cl Chimney op dome	Aisle Seats F C	1.13	6	.86	6a	.96	6w	.92
Lower "	" "	Lamp	Acme Burner	Window Seats av FC	1.01	7	.66	7a	.99	7W	.83
Above Belt	Light Oak	Rating		Car Av. F.C.	1.08	8	.66	8a	.71	8W	.62
Below "	" "	Lumens per lamp		Lumens utilized	452						
Seats	Red Plush	Total lumens		Efficiency							

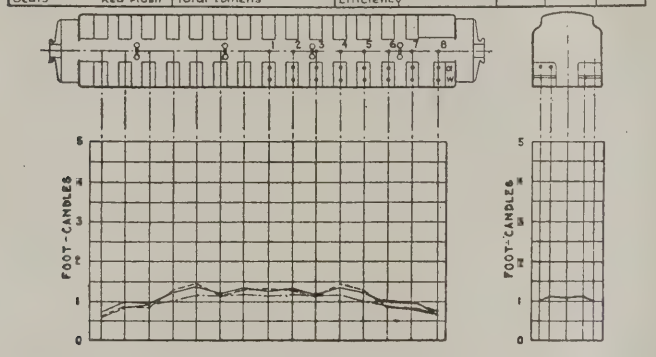

Fig. 5. Two-Light Acme Burner Fixture Test (Running).

CAR		FIXTURES		ILLUMINATION		FOOT CANDLE READINGS					
Class.	Pf	System.	Oil	Test	Standing	1	1.25	1a	1.11	1w	.96
No.	Q.V.R.R. 3210	Fixture.	2 Lt. Center Deck	Reading plane	36"	2	1.18	2a	1.20	2w	1.05
Type.	Wood	Number fixtures.	4	Maximum f.c	1.35	3	.94	3a	1.06	3w	.99
Floor area sq ft	400	Spacing	126"	Minimum f.c	.60	4	1.35	4a	1.26	4w	1.08
Finish.		Height	92"	Aisle av. fc.	1.05	5	1.25	5a	1.18	5w	.97
Upper deck.	Olive green	Reflector	Cl chimney op dome	Aisle seats av f.c.	1.05	6	.83	6a	.89	6w	.85
Lower deck.	" "	Lamp	Acme burner	Window seats av f.c.	.91	7	.93	7a	.94	7w	.79
Above belt.	Light Oak	Rating		Car av f.c.	.95	8	.68	8a	.72	8w	.60
Below belt.	" "	Lumens per lamp.		Lumens utilized	396						
Seats.	Red plush	Total lumens.		Efficiency							

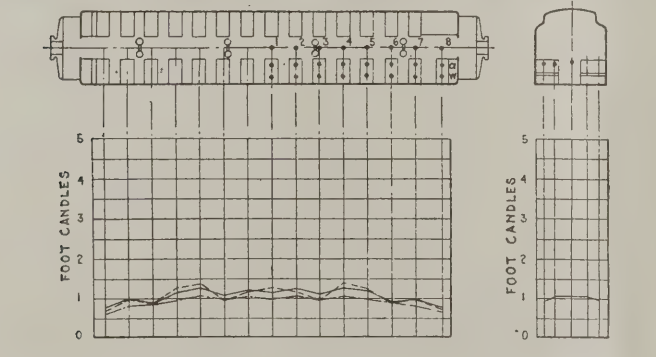

Fig. 6. Two-Light Acme Burner Fixture Test (Standing).

CAR		FIXTURES		ILLUMINATION		FOOT-CANDLE READINGS					
Class	Pf	System Carburetter Gasoline		Test	Running	1	1.46	1a	1.35	1w	1.08
No.	W.J. & S.R.R. 3719	Fixture	1 Lt Center Deck	Reading Plane	36"	2	1.16	2a	1.04	2w	.90
Type	Wood	No. Fixtures	5	Maximum F.C	1.46	3	1.19	3a	1.12	3w	.91
Floor Area Sq Ft.	367	Spacing	80"	Minimum F.C.	.30	4	1.12	4a	1.03	4w	.91
FINISH		Height	90"	Aisle Av F.C	1.08	5	1.44	5a	1.37	5w	1.03
Upper Deck	Olive Green	Reflector	Cl. Globe	Aisle Seats Av. F.C	.98	6	.93	6a	.71	6w	.85
Lower "	" "	Lamp	Inverted Argand Burner	Window Seats Av F.C.	.83	7	.30	7a	.30	7w	.30
Above Belt	Light Oak	Rating		Car Av. F.C.	.94						
Below "	" "	Lumens per Lamp		Lumens utilized	.845						
Seats	Red Plush	Total Lumens		Efficiency							

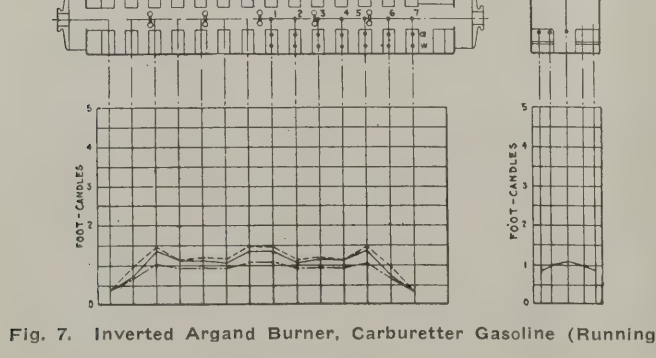

Fig. 7. Inverted Argand Burner, Carburetter Gasoline (Running).

Figure 5 shows a standing test of dual burner oil lamps. This type of fixture consists of two lamps spaced on about 16-inch (40.64 cm.) centers crosswise of the car. Each lamp has two wicks feeding a single flame. Oil is fed through tubes from a common central reservoir. Each lamp was equipped with clear chimney and conical opal glass reflectors. Burners were adjusted so that the center line of the flame was at right angles to the axis of the car.

Figures 6 and 7 show running and standing tests respectively with Acme burner oil lamps. This is a central draft type of burner. Each lamp was equipped with a clear glass chimney and an opal reflector. The

CAR		FIXTURES		ILLUMINATION		FOOT-CANDLE READINGS					
Class	Pf	System Carburetter Gasoline		Test	Standing	1	.134	1a	1.12	1w	.96
No.	W.J. & S.R.R. 3719	Fixtures	1 Lt Center deck	Reading plane	36"	2	.93	2a	.87	2w	.74
Type	Wood	No. fixtures	5	Max. f.c	1.35	3	.74	3a	.70	3w	.65
Floor area sq ft	367	Spacing	80"	Min. f.c	.30	4	.87	4a	.76	4w	.69
Finish		Height	90"	Aisle av f.c	.98	5	1.35	5a	1.15	5w	.98
Upper deck	Olive green	Reflector	Cl. globe	Aisle seats av f.c.	.80	6	.78	6a	.71	6w	.66
Lower deck	" "	Lamp	Inverted Argand burner	Window seats av f.c	.71	7	.30	7a	.30	7w	.30
Above belt	Light Oak	Rating		Car av fc	.78						
Below belt	" "	Lumens per lamp		Lumens utilized	288						
Seats	Red plush	Total lumens.		Efficiency							

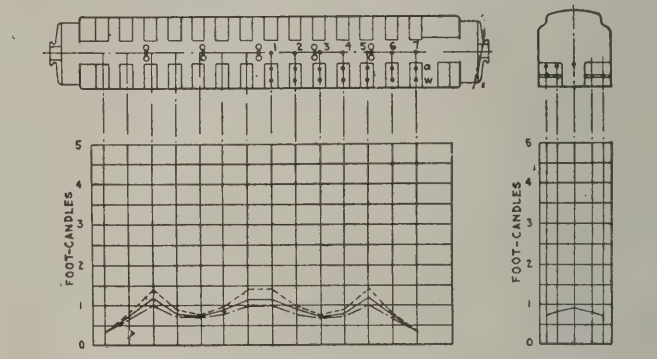

Fig. 8. One-Light Inverted Argand Burner Test (Standing).

CAR		FIXTURES		ILLUMINATION		FOOT-CANDLE READINGS					
Class	Pk	System	Pintsch Gas	Test	Standing	1	1.02	1a	1.18	1w	1.02
No.	1175	Fixtures	2 Lt Center Deck	Reading Plane	36"	2	1.15	2a	1.11	2w	.92
Type	Wood	No. Fixtures	5	Max. F.C	1.18	3	1.07	3a	1.08	3w	.92
Floor Area, Sq Ft.	392	Spacing	106½"	Min. "	.61	4	85	4a	1.06	4w	.90
FINISH		Height	96"	Aisle Av. F.C.	.94	5	.99	5a	.96	5w	.83
Upper Deck	Light Olive Green	Reflector	Cl. 61" 126 Opal 927	" Seats Av. F.C.	.87	6	.99	6a	.91	6w	.73
Lower "	" "	Lamp	Inv. Argand Burner	Window " "	.84	7	.77	7a	.84	7w	.81
Above Belt	" Oak	Rating	21 m.s.c.p.	Car Av. F.C.	.91	8	.70	8a	.65	8w	.61
Below "	" "	Lumens per Lamp	938	Lumens Utilized	.827						
Seats	Brown Plush	Total Lumens	1695	Efficiency	21.1%						

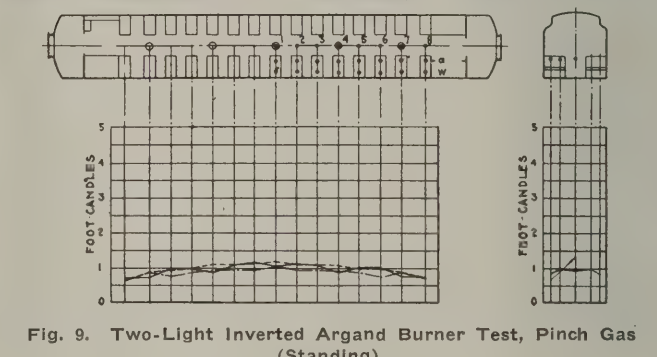

Fig. 9. Two-Light Inverted Argand Burner Test, Pinch Gas (Standing).

CAR		FIXTURES		ILLUMINATION		FOOT-CANDLE READINGS					
Class	Pk	System	Pintsch Gas	Test	Running	1	2.93	1a	2.64	1w	1.78
No	3409	Fixtures	1 Lt Center Deck	Reading Plane	36"	2	2.21	2a	1.92	2w	1.67
Type	Wood	No Fixtures	5	Maximum F C	2.93	3	2.22	3a	2.21	3w	1.76
Floor Area, Sq ft	392	Spacing	106½	Minimum F C.	1.11	4	2.69	4a	2.49	4w	1.73
FINISH.		Height	96"	Aisle av. F.C.	2.52	5	2.19	5a	2.05	5w	1.71
Upper Deck	Pea Green	Reflector	Frosted Globe 3033	Aisle Seats av F.C.	2.08	6	2.09	6a	1.76	6w	1.54
Lower "	" "	Lamp	Large mantle 3044	Window Seats av F.C.	1.60	7	2.26	7a	2.25	7w	1.46
Above Belt	Light Oak	Rating	48.5 m.e.c.p	Car av F.C.	1.93	8	1.29	8a	1.29	8w	1.11
Below "	" "	Lumens per lamp	609	Lumens utilized	757						
Seats	Brown Plush	Total Lumens	3045	Efficiency	24.9%						

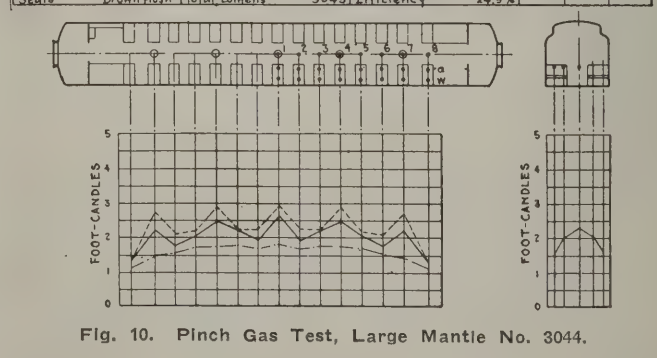

Fig. 10. Pinch Gas Test, Large Mantle No. 3044.

illumination was pleasing and sufficient for newspaper reading. The light interior finish added to the appearance of the car.

Figure 7 and 8 show running and standing tests respectively of central draft types of carburetted gasoline equipment. The burner is inverted in a clear glass bowl. Air from the train system is passed through a spiral tube containing a wick soaked in gasoline, and the resultant mixture passes to the lamp to be burned. The carburetter is placed on the top of the car above the lamp so that the heat of the air raising from the lamp will heat the incoming gas. This type of lamp is very susceptible to changes of temperature and draft, and therefore requires constant attention to prevent smoking, especially during stops at stations.

Figure 9 shows the results obtained by the use of Pintsch gas with inverted Argand burner lamps.

Figures 10 and 11 show running and standing tests respectively of single mantle Pintsch gas lamps. Gas is carried in tanks under the car at a pressure of about

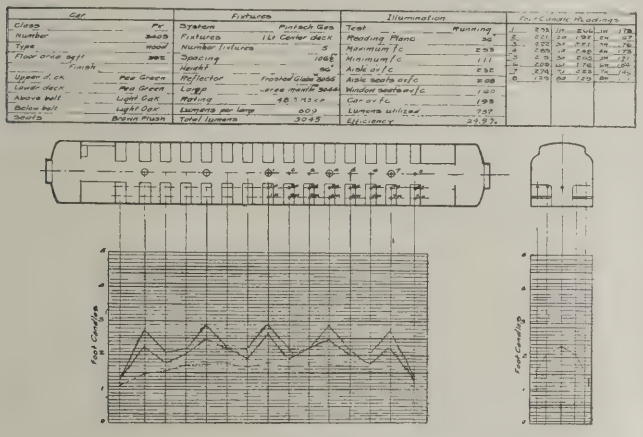

Fig. 11. One Light Pintsch Gas Fixture (Running).

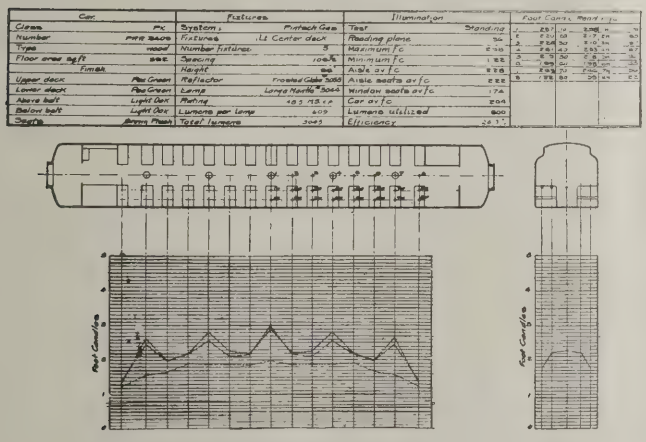

Fig. 12. One Light Pintsch Gas Fixture (Standing).

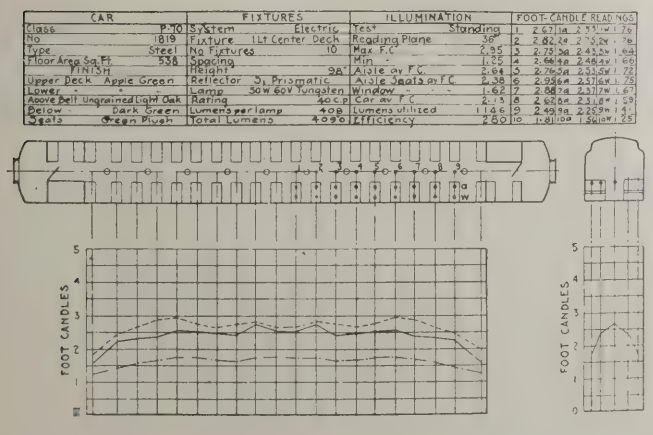

Fig. 13. One-light Electric Fixture (Standing).

150 to 160 pounds per sq. in. (10.5 Kg. per sq. cm.) and is reduced at the lamp to about two pounds per sq. in. (.145 Kg. per sq. cm.). With temperatures below 20 deg. F., some of the hydro-carbons are precipitated with a consequent reduction in illumination. It will be noted that there is practically no difference in illumination between running and standing conditions.

Figures 13 and 14 show the illumination that was obtained in steel cars equipped with 50-watt, 60-volt tungsten filament lamps, the first with flat prismatic reflectors and opal dipped lamps and the latter with

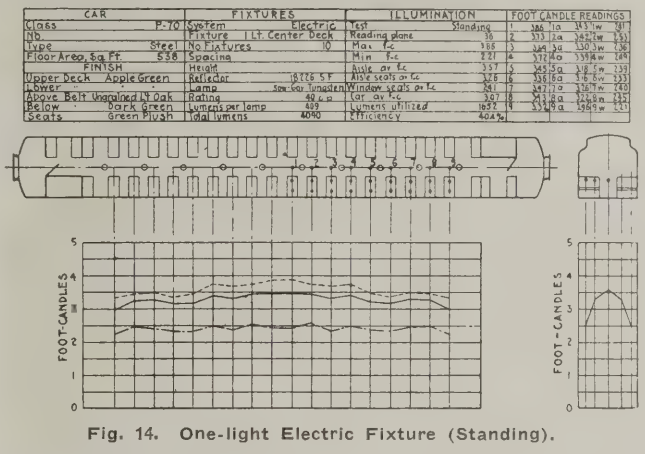

Fig. 14. One-light Electric Fixture (Standing).

satin finish prismatic bowl type reflectors with clear lamps.

Conclusions.

From these tests some idea of the comparative values of the several types of car lighting units may be had. Similar tests of cars varying only in interior color and finish will show changes in efficiency of 100 per cent or more, and other tests of direct, semi-indirect and indirect fixtures will show considerable variation in current consumption. The standard car lighting battery is none too large from a capacity standpoint, while from a weight standpoint it is now as large as it can be made for convenience in handling. Changes in lamp efficiencies will be of little value until they can be increased sufficiently to either reduce the weight or increase the hours of battery service from 25 to 50 per cent. Fixtures, reflectors and color of interior finish should receive further attention with a view of reducing maintenance and operating costs and providing better distribution of light at higher efficiencies. Comparative tests should be made with side deck, semi-indirect and indirect fixtures to determine their value not only from a standpoint of illumination, but from the more important standpoint of current consumption.

THE REGENERATION OF SULPHATED STORAGE CELLS.*

By C. W. Bennett and D. S. Cole.

In a recent article by Mr. G. A. Perley, a method for curing sulphated storage cells was outlined. The work consisted essentially in experiments on the reduction of lead sulphate by three methods, namely, chemical reduction, electrolytic deposition and reduction, and chemical solution followed by reduction. By the first method ferrous sulphate and sodium hydroxide, zinc and hydrochloric acid, zinc precipitated electrolytically on the plates, and aluminum with potassium hydroxide were used as reducing agents. The third reducing agent gave a partial reduction of the

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sulphate, but it was found that in order to get enough zinc on the plate current density had to be increased. However, with the increased current density the zinc precipitated on the best conducting portions of the grid and the lead sulphate, which of course formed the non-conducting part, was found to scale off, due to the increased potential difference required to force the higher current through the solution. Straight reduction, therefore, of the lead sulphate was given up.

Since in the normal working of a cell lead is left in intimate contact with lead sulphate, which is readily reduced, on account of a local couple probably, it seemed best to try precipitating lead on the lead sulphate and then charge the grid in sulphuric acid. This would give, apparently, normal working conditions. In order to do this, lead was precipitated from lead plumbite, lead fluosilicate, lead acetate and lead perchlorate solution. The difficulty found here was, that by "treeing" the lead flaked off and caused a large amount of shedding and hence loss of the active mass. For this reason this method was considered unsatisfactory.

It was found, rather by accident than otherwise, that a sulphated grid, when placed in sodium hydroxide solution, became reduced to lead very quickly. In order, therefore, to obtain a sodium hydroxide solution in the pores of the lead plate, where the largest tendency to sulphate is found, electrolysis with sodium sulphate as electrolyte suggested itself at once. The current should be sent through the cell in the direction of charging; sodium hydroxide will be formed at the lead plate, and sulphuric acid at the lead dioxide plate. Thus an alkaline solution will be formed at the cathode and an acid one at the anode. Now, if the electrode potential for the liberation of hydrogen be measured, a higher voltage is found necessary when an alkaline solution is used than that required for a neutral or acid solution. In the same way a higher voltage is required for the liberation of oxygen in acid solutions. The discharge potentials for hydrogen and oxygen, respectively, will therefore be increased over those in a straight acid solution. In this way the range of reduction and oxidation will be increased, for a higher voltage can be impressed without the liberation of hydrogen and oxygen. Thus, there is a greater tendency to reduce lead sulphate to lead at the lead plate or cathode, and oxidise lead sulphate to lead dioxide at the lead dioxide plate or anode. When this was tried on cells that were uniformly coated with lead sulphate the results were astonishing. Cells with a capacity of one ampere-minute were brought back to their original rated capacity, and in some cases to a capacity over 100 per cent. of the original rating. The concentration of sodium sulphate recommended, which can be varied within wide limits, is 200 grammes of the crystallised salt ($Na_2SO_4 1OH_2O$) per litre. The sodium sulphate should fulfil, as regards purity, the requirement for battery acid, that is, it should be chemically pure. It is not necessary to wash out all of the sodium sulphate; the plates need only be dipped once in water. The time of charging in the sodium sulphate solution, for the worst cells, was about 60 hours, at the 8-hour rate.

In order to verify these results on a larger scale than had previously been tried, it was thought desirable to treat a battery belonging to the Department of Electrical Engineering, of Sibley College, Cornell University. The battery consisted of 52 cells, and had been in use for five or more years with very little attention. The cells were used daily by students in the laboratory, throughout the school year, and had been put out of commission for the summer months in the usual way by removing the plates from the acid, allowing them to stand for 24 hours in water, and then drying. In the spring of 1911 the cells were not allowed to stand long enough in water, and hence were very badly sulphated in the fall. They were put back into commission in the usual way, and were found to have very much less than their rated capacity of 60 amp. hours. During the Christmas holidays the cells were treated by the method above outlined. A capacity and efficiency run was made on the battery before treatment. The power was measured by a watt-hour meter. The current was kept constant at the 8-hour rate, namely, 7½ amperes. The results of this first run are given in Table I. below:—

Table I.—Efficiency and Capacity Test Before Treatment.

Total input	7,150 watt hours
Total output	3,040 watt hours
Ampere hour hour output	30.6 ampere hours
Energy efficiency	4.5 per cent.
Energy capacity, of rated	48.7 per cent.
Ampere-hour capacity, of rated	51.0 per cent.

From this it can be seen that the active mass of the cells was about half converted into sulphate in the non-available form when used in the ordinary battery acid. After this the acid was removed, the plates dipped in water, and the jars filled with a solution of chemically pure sodium sulphate. The anhydrous salt was used and the solution contained 10 per cent. of this salt, by weight. This corresponds to 22½ per cent. of the crystallised salt, if this be used. The battery was then charged in the usual way at the 8-hour rate for 53 hours. A motor generator was used to supply the power necessary. The generator was driven by a three-phase induction motor. The power being available only from 6 a. m. to 12 p. m., an automatic device was employed for starting and stopping the experiment by opening and closing the generator circuit. The induction motor was left across the line at night. As it is customary to build up the voltage from 0 to 2,200 volts at the power-house, without disconnecting the transformers from the line. the motor started easily without giving any trouble. In the morning the battery circuit had to be closed when the generator was delivering about three-fourths of the voltage required for normal running, for owing to the diffusion of the electrolyte the back electromotive force of the battery had dropped during the night. A solenoid was therefore designed to close the generator circuit at about three-fourths full-load voltage on motor.

In order to get a capacity and efficiency test the battery was then discharged, charged, and discharged a second time. The results after this treatment are shown in Table II.:—

Table II.

First discharge, output	5650 watt hours.
First charge, input	6820 watt hours.
Second discharge, output	5530 watt hours.
Ampere hour output	58.1 ampere hours.
Energy efficiency	81.1 per cent.
Ampere hour capacity, of rated	96.9 per cent.

The conclusions drawn from this experiment may be summed up as follows:—(1) Badly sulphated cells can be economically regenerated by electrolysis in sodium sulphate solution. (2) The cost need not be greater than 20 cents per cell. (3) Allowing 5 cents per kw. hour for power, the increase in the efficiency of the cell will pay for the regeneration in about 90 charges and discharges, or in about 3 months' daily use.

School of Electricity

Lesson No. 2

A Course of Training Prepared by the Pennsylvania Railroad for Its Employes

EDITOR'S NOTE:
Through the courtesy of the officials of the Pennsylvania Railroad, we have been given special permission to publish this entire course in the *Railway Electrical Engineer*, so this valuable training in electricity, which was originally intended only for P. R. R. men, now becomes available to all railroad men. A complete lesson of this course will be published in each issue.

DIRECT CURRENT.

INSULATORS.

Substances which have sufficiently high resistance to prevent any appreciable flow of current in electrical transmission are called non-conductors, insulators or dielectrics. As a general thing, all the metals and solutions of their chemical salts are classed as conductors, while the other substances or compounds then come under the head of insulators. In the ordinary construction, these insulators are applied to the conductors of the circuit to direct the flow of current along the path of the conductor. Strictly speaking, there are no known substances which are absolutely perfect insulators, as even the air is now used through which to transmit wireless telegraph signals for thousand of miles, and wireless power transmission has been considered.

The value of any substance as an insulator depends upon the conditions under which it is to operate. The first and most important condition which it must meet is the resistance to puncture or break down under the highest voltage and the worst service conditions to which it will be subjected in actual service. These conditions, such as high temperature, moisture, mechanical stress in the form of tension or compression, chemical vapors, or injurious gases from furnaces or coke ovens, excessive vibration, etc., are the worst, and should be considered in deciding upon the type of insulator to be used.

The insulating material may be applied to the circuit in two general ways. One is to support the conductor from point to point in such a manner that it does not come in contact with any other bodies. The substances with which we are familiar for this purpose are wood, glass, fibre, hard rubber and porcelain. These are formed or moulded into different shapes, such as knobs, tubes, insulators, etc., to meet the particular requirements.

Another method is to insulate the conductor its entire length by means of a continuous covering, which is applied on each conductor to prevent its coming in contact with other conductors. The approved composition of this insulating covering depends entirely upon the conditions to be met. For example, in some lead-covered telephone or telegraph cables, dry paper is recommended, as it has good insulating qualities, and does not take up much space. This makes it possible to place a large number of conductors or wires in a comparatively small sheath or outer covering. The subject of cables will be taken up more in detail in a later paper. The most common insulator for wire is some form of rubber or its compounds, and this is usually covered with an outer braiding of one or more layers of cotton or hemp to prevent mechanical injury and oxidation of the rubber. This outer covering is usually saturated with some moisture proof insulating compound.

The Relative Values of Some of the Insulating Materials.

To Withstand High Temperature.

Adit,	Berrite,	Leatheroid,
Aetna,	Celluloid,	Mineralite,
Ambroin,	Electro-enamel,	Mica,
Asbestos,	Hornfiber,	Sterling Varnish.
Armalac,	Lava,	

When moisture collects on the insulator, it increases very appreciably the surface leakage, and when it is absorbed by the insulator, it greatly diminishes the resistance of the insulator. This moisture not only reduces the efficiency of the insulator, but it may also act injuriously upon the quality of the insulator itself.

For Moist Places.

Adit,	Asphalt,	Hornfibre,
Aetna,	Ebonite,	Leatheroid,
Ambroin,		Presspahn
Armalac,	Efectro-enamel,	(treated)
Celluloid,	Gutta-percha,	Rubber.

To Withstand Large Tension or Compression Stresses.

Adit,	Hornfibre,	Mineralite,
Aetna,	Lava,	Presspahn,
Ambroin,	Leatheroid,	Psychiloid,
Celluloid,	Megomit,	Vulcanized
Ebonite,	Megotalc,	fibre.
Fullerboard,	Micanite,	

Adit, according to the makers, is tough; can be moulded into any shape; does not shrink so that it can be made to exact dimensions. It is not affected by moisture, and will work satisfactorily at temperatures up to 60° or 120° C., depending upon the quality. Will withstand compression up to 1,800 pounds per square inch and from 500 to 800 volts per millimeter (mm) thickness, depending upon the thickness.

Aetna material is used for strain insulators. A strain insulator of this material was found to have the following properties: It punctured at 1,000 volts; insulation resistance, 20,000 megohms; tensile strength, 2.46 tons; immersed in water at 49° C. it absorbed .0317 of its own weight in 1.5 hours. This material will withstand great heat, but is inclined to be brittle. At ordinary temperatures, it has withstood as high as 1,400 pounds per square inch and a compressive strength of 728 pounds per square inch.

Ambroin, according to the makers, is not affected by moisture; it will stand very high temperature; it can be moulded into any form; it does not shrink and it can be machined. Its specific gravity varies from 1.4 to 1.8, depending upon quality. Its specific resistance is about 160,000 megohms per cubic centimeter. The tensile strength is greater at from 50° to 70° than at ordinary temperatures. At ordinary temperatures this has shown on test a tensile strength of 2,140 pounds per square inch and a compressive strength of 2,680 pounds per square inch.

Armalac is an insulating varnish, which has many good points claimed for it. Its melting point is over 300° C., yet it never becomes brittle. It is claimed to be a black paraffine in a solution of petroleum naphtha, the melting point of the paraffine having been raised by a secret process. It will absorb oil and be benefited by it. It contains no acids which can be liberated to attack the conductors. Its insulating value is not high, but is claimed to be very constant. It penetrates to the conductors and effectually prevents oxidation. It can be applied by dipping the object into it or it may be applied with brush same as any other varnish. Armalac putty may be made by mixing it with whiting. This is a very good conductor of heat.

Asbestos is used in insulating work on account of its heat-resisting qualities. It is made in the form of board, paper, tape, etc. Tests have shown asbestos paper to withstand 4,500 volts per mm., for a specimen 0.6 mm. thick.

Asphalt is used chiefly in conduit work, is not affected by water, is very ductile and may be easily and cheaply repaired.

Berrite is an impregnating gum. It is brittle, but withstands about 5,000 volts per mm. It runs freely at low temperatures, but its insulating qualities are not affected by great heat. Is good for impregnating cloth or paper, but paper so treated must be handled carefully to prevent cracking.

Bitumen is an excellent insulator at ordinary temperatures. It flows freely at a little above 100° C. Its dielectric strength is very high, being 12,000 volts per mm. for a thickness of 2.5 mm. Its resistance is high and is chemically inactive.

Celluloid is a very good insulating material, will work in temperatures up to 100° C., absorbs moisture only to a very slight degree, can be moulded into any form by soaking in boiling water. The safe working pressure is about 14,000 volts per mm. at 20° C., and 6,000 volts per mm. at 100° C. Colored celluloid seems to have a higher dielectric strength than the clear. When soaked 27 hours in water the increased weight was only 0.183 per cent. Its specific gravity is 1.44.

Celluloid lacquer is a most excellent material for insulating laminations. If the iron is warm when immersed in the lacquer, it will dry quickly, giving a very thin, uniform coating of very high resistance. This coating is not affected by heat, moisture or acids.

Ebonite is a kind of hard rubber. It contains sulphur, and is therefore affected by the air, which oxidizes the sulphur at the surface. This action is very rapid and destructive where ozone is present (around electric generators). It is attacked by oils and should never be used when it will come in contact with oil. It is brittle, but quite strong. At ordinary temper-

atures it has tensile strength of about 1,100 pounds per square inch and about twice this for compression. Its strength is greatly diminished by higher temperatures. Its dielectric strength is comparatively high, being about 35,000 volts per mm., with specific resistance of 28,000 megohms per cubic centimeter.

Vulcanite is practically same as ebonite.

Glass has a high dielectric strength, about 12,000 volts per mm. and for continuous voltage of about 83,000 volts per mm. Common window glass has specific resistance of 6,600,000 to 8,200,000 megohms per cubic centimeter, the higher resistance being obtained from the lower voltage. Water readily condenses on the surface, and rain water dissolves enough of the glass to slightly roughen the surface so that dirt, soot, smoke, etc., accumulate. When this becomes moist, the line leakage is very appreciable. Experiment has shown that glass in which potash was used in the manufacture has higher resistance than the glass using soda. The resistance is also increased by annealing. It is suitable for line insulators on low or medium voltage circuits, but not adapted for high-tension work. It can be easily inspected for cracks, dirt or other imperfections. On account of the varying composition, it is easily broken by only slight blows or stresses. In many places it is being replaced by porcelain on the low voltage telephone and telegraph circuits.

Gutta-percha is very valuable as an insulation if it can be protected from air and light, both of which act to oxidize it. If submerged in water or protected by lead sheath, this oxidation is hardly perceptible. Experiment has shown it to have a specific resistance of 450,000,000 megohms per cubic centimeter. It weighs less than water, as its specific gravity is 0.969 to 0.981. A negative temperature coefficient is shown as its resistance decreases very appreciably with increases in temperature. At 46° C. it softens, is plastic at 50° and melts at 100°. The dielectric strength of untreated gutta-percha varies from 10,000 to 25,000 volts per mm., the higher values being for the thinner specimens.

Hornfibre outranks other fibrous materials, although more expensive. Its mechanical strength and insulating properties are both relatively high. This has dielectric strength of 1,000 volts per mm. untreated, but this can be approximately doubled by treating with oil or varnish.

Lava is a mineral talc and is becoming a very important insulating substance. It is not attacked by any of the acids or alkalies, except hydrochloric and then only slightly. It can be machined, and does not shrink nor expand from the effects of moisture and but slightly from heat. After having been machined, it is baked to 1,100° C., making it extremely hard.

Marble is used largely for switchboards. It should be carefully examined to make sure that it is free from all traces of metallic veins.

Mica, which is used very extensively, is one of the most valuable insulating materials. In nature, it is of a rock formation and is a silicate of aluminum and potassium or sodium. Different proportions of the elements forming it fix the colors of it, whether light or dark. This is used largely in the construction of very delicate electrical apparatus as well as the heavier and more rugged construction. This may be split down as fine as .006 mm. The dielectric strength varies from 17,500 to 28,500 volts per mm., depending upon the composition of the specimen. Its specific resistance varies from 2,300,000 to 40,000,000 megohms per cubic centimeter. It is the principal constituent in the compounds, micanite, megomit, megotalc, etc.

Paraffine is used largely to impregnate insulating cloths, papers, etc., and in lead-covered cable work to exclude moisture from splices and taps. It melts at about 65° C. and has a dielectric strength of about 8,000 volts per mm. Its specific resistance is from 240,000,000 to 3,900,000,000 megohms per cubic centimeter.

Porcelain is largely used for line insulators, knobs, fittings, switch bases, etc. The specific gravity is about 2.42; tensile strength per square inch 1,800 pounds; compression strength per square inch 15,000 pounds; dielectric strength 16,000 volts per mm. At very high temperatures it loses its properties, becoming a fair conductor.

Rubber. The various compounds of rubber are very extensively used for insulated wires and cables. Several different gums are used, but the one giving most satisfactory results is known as Para. This is usually specified for high grades of wire, but it is extremely difficult to make tests to determine the exact composition of rubber compounds. It is vulcanized by heating to 120° to 150° C. and mixing the proper amount of sulphur. Higher temperatures produce hard rubber compounds known as ebonite and vulcanite. Good authorities show the following for good 30 per cent. Para rubber insulations: Tensile strength, 800 lbs. per sq. in.; set not greater than 18.75 per cent after stated time; specific resistance, 1,770,000,000 megohms per cubic centimeter; the temperature coefficient of resistance should not exceed 4.7 per cent per degree C.

There are many other substances used to a greater or less extent, and each will be adapted to some particular class of work, but it is impossible to treat them all in this work. The following table gives a number of the more important insulators:

TABLE No. 9.—RESISTACE OF INSULATORS.

Insulator.	Megohms per Centimeter Cube.
Mica	4×10^6 to 84×10^6
Gutta-Percha	449×10^6
Shellac	1500×10^6 to $9,000 \times 10^6$
Ebonite	$4,000 \times 10^6$ to $28,000 \times 10^6$
Paraffine	240×10^6 to $34,000 \times 10^6$
Paraffine oil	8×10^6 to 110×10^6
Glass, flint	9×10^6 to 20×10^6

As there are no materials which are perfect insulators that would prevent absolutely the flow of current, no matter what the voltage, neither are there any materials which are perfect conductors, having no resistance. There are all gradations between the best conductors and the best insulators, so that in speaking of a good conductor or a good insulator, the term is merely relative the same as the terms hot and cold.

LINE INSULATORS.

The insulating qualities of new glass or new porcelain insulators are very much higher than that of similar insulators after having been in use where they are subjected to the various weather and service conditions. This lowering of the insulating qualities is caused by a deposit of soot or dirt on the surface of the insulator. This deposit seems to act more injuriously upon the surface of glass than on the porcelain insulators, as there is a certain chemical action which takes place between the glass and this deposit which eventually roughens the surface, causing dirt to adhere to it more readily.

Fig. 7.
Pony Insulator.

Fig. 8.
Deep Groove Glass Insulator.

A heavy rain will wash off the dirt from new glass insulators, but when they become roughened by this chemical action, they will not clean themselves in this manner. A well-glazed porcelain insulator is not attacked by this chemical action and for this reason maintains a more uniform insulation than the ordinary glass.

The line leakage in wet weather is not through the insulators, but over their surface to the other wires and to the ground. This is overcome very largely by so designing the insulator that there are deep grooves underneath and between the outer surface and the supporting pin or bracket. The portions of the insulator formed by these grooves underneath are called petticoats and are illustrated in the cuts of the telephone insulators known as "Deep Groove Double Petticoats" Fig. 10, and are also in the high voltage insulator having a number of very marked flanges or petticoats. Fig. 9.

Glass has been used very extensively for telephone, telegraph and low voltage transmission systems, but there is quite a tendency at the present time to use porcelain instead. Porcelain is used almost exclusively for the high voltage systems.

There are arguments in favor of each type, but there are more points in favor of a good grade of porcelain than for glass.

One great menace to the insulating properties of any open or aerial line construction, especially in wooded or country sections, is the formation of cocoons in the grooves underneath the insulator. When these become moist in damp or foggy weather, a short path to ground is formed, greatly reducing the line insulation. Spider webs between the wire and arm are also bad in wet weather.

Glass has some disadvantages, among them being its brittleness, many times being entirely shattered by a slight shock. Moisture condenses on its surface in damp weather much more readily than on porcelain. Molded glass, although more generally used than blown glass, is inferior to the latter. The cost

of the blown insulator makes its use almost prohibitive. The formation of cocoons on the under surface is more readily detected with the glass than with porcelain.

Poreclain is strong; does not have its surface roughened by the action of the ordinary deposit, which facilitates the cleansing process during a rain storm; is not so readily shattered or broken by a blow or shock as glass.

Different types and sizes of insulators should be used for different classes of line construction and too great care cannot be taken in studying this feature of the line. An insulator that would give excellent service for a telephone or telegraph line would fail if used for a high voltage power transmission line.

Fig. 9.
Three-piece Porcelain Insulator For High Tension Lines.

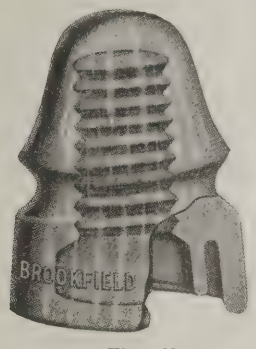


Fig. 10.
Deep Groove, Double Petticoat Glass Insulator.

The high voltage insulator could be used for the lower voltage lines, but their cost would be prohibitive. Thus, not only the electrical efficiency, but also the cost must be taken into consideration in planning any new line work, as it would be a needless expenditure to use the large power insulators for low voltage circuits when the smaller types serve well under the worst working conditions ordinarily met in practice. The insulators for any class of construction should be so designed and installed that service will be maintained under the worse operating conditions and so that the minimum loss due to leakage will be experienced. This many times involves a careful study of all operating conditions, and if the line is very long or if the service is heavy and also important, then the expense involved in securing the correct design and material to begin with it is a wise one, for the reason that the losses extend over a period limited only by the life of the line.

One feature in line construction and other installations, which is prevalent to a greater or less extent under many foremen, is the temporary work which is put in with the intention of removing it in a short time to be replaced be permanent construction. This is allowed to pass for a considerable length of time until it is forgotten and is then responsible for trouble which may develop sufficiently to cripple the whole system. It is more economical, as well as more satisfactory, to do good, permanent work to begin with than to install a makeshift to be replaced in a short time, for the reason that what has been done must necessarily be removed and replaced and possibly the material thrown away which was in the temporary installation.

ELECTROLYSIS OF UNDERGROUND CABLES.

This is a very serious trouble which is met especially in towns having underground cable systems and an electric trolley system using a ground return. Even though the track may be carefully bonded with copper conductors, there is sure to be a certain leakage which will find its way back to the power house through the earth.

Although these cables are usually laid in non-conducting conduits, yet there is always more or less moisture on their inner surfaces which serve as a path for current to and from the cable.

If there are any lead-covered cables, gas or water mains, or metallic conduits in contact with the earth and which parallel the track or which extend through sections having a difference in potential of but a few volts, there will be very appreciable currents flowing through them, as they have a low resistance. The action upon the sheath of the cable seems to be greatest nearer the power house where the current leaves the main or sheath, providing the negative side of the generator is connected to ground, and is noticeable from the fact that the sheath or pipe is usually pitted at that point very appreciably.

The difference in potential in different parts of some cities runs as high as fifteen to twenty volts, and even a hundredth of a volt could be considered dangerous for the sheath.

Whenever a direct current passes through water the latter is decomposed into the two gases of which it is composed—oxygen and hydrogen. The hydrogen collects at the point where the electricity leaves the water when it enters the cable, while the oxygen appears where the current enters the water; that is, where it leaves the cable. Hydrogen is harmless to the metal sheath and even prevents corrosion, but oxygen, when just liberated, attacks the lead or other metal and is responsible for the pitting of the surface. This pitting eventually goes through the metal and is responsible for the trouble.

The earth always contains certain salts and compounds which, when moist, act as an electrolyte, considering the cable sheath as one pole of a battery. The passage of the current promotes the chemical action. Some metals are attacked more than others in this process, lead being the most sensitive, wrought iron less, while cast iron—especially the hard white cast iron—is very free from these attacks. Many cities have adopted a system of wood water mains which eliminate this trouble for this system.

A slight pin hole in the sheath of a lead-covered cable is sufficient to admit moisture, causing an entire section of cable to go in trouble, as the conductors are ordinarily insulated with dry paper. As these cables in many cases have as many as one hundred to four hundred pairs of wires, and when the moisture once enters it, that section is no longer fit to use, but must be junked, the seriousness of this trouble can be appreciated. This electrolytic action is no respecter of cables and is just as apt to attack the busiest trunk line cables over which thousands of messages are handled daily as the one used occasionally. This fact only emphasizes the very great importance of making the installation in every case in such a manner that the cable will be as nearly as possible proof against this action.

Means of Preventing Electrolysis.

Using two wires or metallic trolley circuits.

Using alternating current for trolley circuit.

If a single wire trolley system using ground return is employed by the traction companies, and this has been upheld by court decisions, then the prevention of the damages must be taken care of by applying devices to the cable itself. If it were possible to make a practical covering for the cable which would be a non-conductor, or if the current could be made to leave the cable where the ground was dry and no chance for electrolytic action, or if the conduit could be kept dry and made of insulating material, then this trouble could be considered as cleared in a very practical way. As yet, these are not on a practical basis. Some companies use an insulated joint in the cable sheath with fairly good success, but this also has its faults, as the joint itself is very liable to have or to develop holes which would admit moisture.

No matter how carefully the rail joints and rail bonds may be made there is sure to be some leakage to earth, which would mean that there are chances for this current entering the cable.

The practice with many telephone companies is to bond together the sheaths of all the cables in a manhole and connect this to a permanently moist earth, or to the rail of the railway system. A better practice is to connect to a return feeder, if these are used by the trolley company. In some cases where this trouble is too serious, copper conductors of sufficient size to carry the current are run direct from the telephone manholes to the generating plant and connected to the feeder bus bars.

The pipe used in the air lines laid in the ground along the tracks of electric railways are often attacked by electrolysis unless special precautions are taken to prevent. These air lines are used for the operation of the electro-pneumatic signals, and it is absolutely necessary that they operate correctly for the movement of trains. Leaks in this air line caused by the action of electrolysis would, therefore, cause serious difficulty.

This trouble may be eliminated by careful bonding to the track or by the use of return feeders. The particular type of bond best adapted would be determined to a certain extent by the character of the electric circuit of the signal system with which it is used, also by the kind of pipe and the coating of it. On account of the electrolytic action which takes place at the junction of two unlike metals and the consequent corrosive action at this point, it is not advisable to use bare copper bonds on iron rails or iron pipe. The ends of the copper at least should be tinned. This also facilitates soldering or sweating the connection.

ELECTROSTATICS.

The preceding pages have referred to electro-magnetic units or terms. Another division with which it is well to be familiar is known as electrostatics. The name means electricity at rest, not current electricity.

Certain conditions in power, telephone and telegraph transmission are brought about by the pressure of the so-called static charge and discharge and have a very appreciable bearing on the line construction, the design of the terminal and protective apparatus to overcome these effects. Some of the experiments used to illustrate the principles of this may seem in no way associated with the above line conditions, but their connection will be seen later.

When a glass rod or piece of amber is rubbed with silk or fur they have the property of attracting small pieces of silk, wool, feathers, paper, gold leaf, pith, etc.

If sealing wax or hard rubber are rubbed with flannel or cat's fur the opposite effect will be noticed.

The charge produced on the glass rod by rubbing it with silk is termed positive, +, while that on the sealing wax rubbed with flannel is termed negative, —. In either case the charge is not produced alone, but an equal amount of the opposite charge is produced on the substance with which the rod is rubbed; thus, the silk will have the same amount of negative charge as the glass rod has positive and the flannel will have the same amount of positive charge as the sealing wax has negative.

In order to produce the greatest charge on the bodies thus treated it is necessary to bring every portion of the surface of plished, additional rubbing or friction will not increase the each into intimate contact with the other. After this is accomcharge on either body.

The following is a table by which the nature of the static charge can be determined when the substances are rubbed together. Any of the substances receives a *positive* charge when rubbed with any substance following it and a *negative* charge when rubbed with any that precede it:

TABLE NO. 10.—ELECTROSTATIC SERIES.

1. Fur.	6. Cotton.	11. Sealing Wax.
2. Flannel.	7. Silk.	12. Resins.
3. Ivory.	8. The body.	13. Sulphur.
4. Crystals.	9. Wood.	14. Gutta-percha.
5. Glass.	10. Metals.	15. Gun Cotton.

To illustrate: Glass rubbed with flannel has negative charge and the flannel is positively charged, but when the glass is rubbed with cotton or silk the glass becomes positively charged.

In speaking of elevation, the point of zero elevation is taken at sea level, both for water systems and for general altitude measurements. Similarly the earth is considered as possessing zero electrical potential or pressure and to be one large reservoir of electricity having a limitless quantity.

It is on this account that it is necessary to insulate all lines from the earth connections to prevent the current or charge from going to earth, as electricity always flows toward a point of lower potential or head. In this manner again the electric circuit behaves much the same as the water system.

It is because there is a better path to ground in wet weather, caused by the leakage over the insulators and down the wet poles, that there are greater line losses then than in dry or fair weather. This emphasizes the importance of maintaining a very high degree of insulation, especially in long circuits where the almost inappreciable leaks that occur on each insulator are multiplied as many times as there are insulators on the lines, which makes a very bad condition taken in the aggregate.

One body charged with positive electricity attracts another body negatively charged and opposes one positively charged. Thus, bodies with like charges repel each other while those with unlike charges attract each other.

A body said to be positively charged possesses a higher potential than the earth, while one negatively charged has potential lower than the earth. It has been assumed for clearness that a charge flows from a positively charged body to one negatively charged when brought into contact with it; that is, that the positively charged body has higher potential or pressure than the one negatively charged.

This current flow takes place until an equalization is reached and the flow is called a current of electricity. If the quantity of electrification is limited, as in the case of the Leyden Jar, which will be explained later, then the current is temporary, but if this potential is maintained then the current is continuous, as is the case with the primary cells. In the former case this transferal of charge often manifests itself in the shape of a spark, jumping from one body to another through the air, which equalizes their potential.

The doctrine of the Law of Conservation of Electrical Energy is that the total mount of positive electricity in the universe is **exactly** equal to the total amount of negative electricity. In other words, for every amount of positive electricity generated there is a corresponding amount of negative electricity.

In the above it has been understood that to transfer a charge from one body to another the bodies must come into contact with each other. It may be proved by experiment that a charge may be transferred from one body to another without actually coming in contact with it. In the latter case the charge is said to be "induced" and the charge an "induced charge."

Distribution of Charge.

A static charge lies wholly upon the outer surface of the body charged, is densest where the curvature of the body is greatest and is independent of the substance of the conductor. The charge on a sphere is therefore uniform, but on an egg-shaped body it is greatest at the small end. From these statements it will be seen that the charge will be greatest at projecting points where the curvature is sharpest and discharge takes place most readily there. For this reason points and sharp edges are avoided in the design of apparatus to be used with static electricity, unless it is desired that a charge or discharge should take place there, in which case they are purposely provided.

The region surrounding a charged body is called an electrical field.

If pith balls are suspended by small threads and brought into the field of a charged body they will be attracted or repelled by the presence of this charged body. When several pairs of these pith balls are suspended at intervals along a conductor and a charged body brought near the conductor a charge is induced in the conductor, as is shown by the behavior of the pith balls. If the charging body has a positiye charge then the nearest end of the conductor suspending the pith balls will have a negative charge induced and the opposite end an equal positive charge.

Although electricity does not ordinarily flow through glass yet it acts across it by induction. When two pieces of tin foil are pasted to opposite sides of a sheet of glass and charged, one with positive and the other with negative, the charges will attract each other; that is, they are held or bound. *Electrostatic capacity* is that property which the two conductors on opposite sides of the glass, dielectric, possess when they can hold and accumulate these static charges.

The ordinary *Condenser* in Fig. 11, used extensively in signal, telegraph and telephone work, possesses this property of holding and accumulating a quantity of static electricity on surfaces of tin foil insulated from each other usually by wax paper as the dielectric.

A common form of condenser used in laboratory work is known as the Leyden jar, and consists of a glass jar coated outside and inside with tin foil for about two-thirds its height. A metal rod extending two or three inches through the stopper, which must be dry and an insulator, and down into the jar, the lower end of the rod being provided with a short metal chain which will touch the bottom of the jar, is used for charging and discharging the jar.

The jar is charged by bringing the end of the center rod, which is usually provided with a ball or disc, into contact with a charged body, the outer coating being connected to earth either through the hand or otherwise. A greater charge may be imparted if this outer coating is connected to ground than if there is no chance for the repelled charge to pass to earth. The capacity of a Leyden Jar or condenser depends directly upon the area of the plates, the larger area having correspondingly larger capacities. The jar is discharged by connecting between the outer coating and the knob. This may be done by bending a wire or other conductor into a V shape, supporting it with some insulating material for a handle, touching the outer coating with one end of the wire and the knob with the other. It will be found that a second and third spark may be obtained from one charge, but the subsequent sparks are not as large as the first. This is known as the *Residual Charge,* which was seemingly absorbed by the glass or dielectric.

The capacity of a condenser is not determined in any way by the thickness of the conducting plates, but is fixed by their area.

The capacity is also dependent upon the thickness of the insulating plate or dielectric separating the conducting plates, it being inversely proportional to this dimension; that is, the thicker the dielectric the less the capacity. Any substance which will admit of electrostatic induction through it is called a dielectric and as different substances possess this quality in varying degrees, the capacity of the condenser is determined largely by the material.

When the same area of plates and the same thickness of dielectric are used the capacity is then dependent upon the material in the dielectric, or, in other words, upon the "Inductive Capacity" of the dielectric. The "Specific Inductive Capacity" of a dielectric is the ratio of the inductive capacity of the substance to that of air.

For example, paraffine paper used as a dielectric in a condenser will admit twice the charge on the plates as could be obtained if the plates were separated the same distance by a layer of air.

The unit of quantity of electricity in known as the "Coulomb," and is that amount which would pass through a circuit in one second if the current is one ampere.

The unit of capacity is known as the "Farad," and is that capacity which requires one coulomb to charge it to a potential of one volt. That is, a conductor or condenser capable of holding one coulomb at a pressure of one volt has a capacity of one farad.

The unit most commonly used in practice is the Microfarad (M. F.), which is one millionth of a farad.

From the foregoing, then, the capacity of a condenser depends

upon the area of the conducting plates, the material used as dielectric and the thickness of the dielectric.

The rating of condensers is based upon the charge they will hold at a potential of one volt, but the amount of the charge which they can hold varies directly with the voltage impressed upon the terminals of the condenser. With the 2 M.F. condenser there would be only 0.000002 coulombs in the charge if 1 volt was impressed across its terminals. This would be increased to .000048 coulombs if the voltage was increased to 24.

The capacities of two condensers may be readily compared by discharging them through a high resistance voltmeter, if they have been charged to the same voltage or potential. The volume of the charge is proportional to the capacities of the two condensers. The capacities of the two condensers are proportional to the throw of the needle, so that if the capacity of one condenser is known the other can readily be determined by this experiment. An instrument with a comparatively heavy, slow-moving needle is better for this purpose. The throw of the needle is caused by the instantaneous impulse from the condenser and is called the "condenser kick" of the needle.

While the charge is held on the condenser plates the dielectric is under a strain. If the impressed voltage is raised sufficiently the strain increases until the dielectric reaches its break-down limit, and the condenser discharges itself through this ruptured surface. Lightning striking a line is responsible for trouble in condensers many times if the apparatus is not properly protected with arresters at the sub-stations or points where the condensers are installed.

The specific inductive capacity or inductivity of a number of dielectrics is given in the following table. Air, as previously stated, is considered as 1.

TABLE No. 11.—SPECIFIC INDUCTIVE CAPACITY OF DIELECTRICS.

Glass	3 to 10	Shellac	2.95 to 3.60
Sulphur	2.24 to 3.84	Mica	4 to 8
Vulcanite	2.50	Quartz	4.5
Paraffine	1.68 to 2.30	Turpentine	2.15 to 2.45
Rosin	1.77	Petroleum	2.04 to 2.42
Beeswax	1.88	Water	.73 to 90

The formula for determining the capacity of a plate condenser is as follows:

$$C = 885 \times 10^{-16} \times \frac{KA}{X} \qquad \text{eq. (15)}$$

C is in farads.

K is inductivity of dielectric.

A is area in square centimeters of all layers of the dielectric between the plates.

X is the thickness of the dielectric in centimeters.

Example: What is the capacity of the condenser made up of tin foil and paraffine paper if there are 100 layers of the wax paper 15 by 30 cm. and the dielectric is of paraffine sheets, .01 cm. thick?

Solution: From the table the average inductivity of paraffine is 2 = K. The area of the plates is $15 \times 30 \times 100 = 45{,}000$ sq. cm. = A. X = .01. Then by substitution in equation 15

$$C = \frac{885 \times 2 \times 45{,}000}{10^{16} \times .01}$$

$$= \frac{1{,}770 \times 4{,}500{,}000}{10^{16}}$$

$$= \frac{7{,}965{,}000{,}000}{10^{16}}$$

$$= .7965 \times 10^{-6} \text{ Farads.}$$

As the quantity 10^{-6} is another way of expressing one-millionth and as the microfarad is one-millionth of a farad then this can better be expressed as .7965 M. F., which is practically .8 M. F.

By this formula it is easily possible to determine what shall be the thickness of the dielectric if the other dimensions and capacity are known or if the number of sheets and their thickness are known together with the desired capacity their size can very readily be determined.

If an electrolytic cell is connected to the terminals of a condenser, momentary charging current will flow from the cell to the condenser. The value of this current falls off very rapidly from the first current rush or impulse to zero in the small fraction of a second. As soon as the condenser becomes charged to the potential of the battery to which it is connected no further current will flow, and it has the same effect upon the direct current as would be obtained by breaking the circuit.

The counter electro-motive force (E. M. F.) or opposing force developed in the condenser by charging it prevents a further flow of current through it.

This charge remains in the condenser after the battery supply has been removed and will be held there until there is some connection between the condenser terminals. The condenser kick mentioned is obtained when a voltmeter is connected in the discharge circuit. This discharge current is similar in form to the charging current, being greater when the circuit is first closed and rapidly falling off to zero.

The name of a condenser is usually determined by the nature of the dielectric used as air condenser, paraffine condenser, mica condenser, etc.

The two wires of a transmission line and the air space separating them may be considered as the two plates and the dielectric, respectively, of a condenser; similarly the paper and air separating the two conductors of a paper insulated cable. This subject will be taken up more in detail in a later paper.

The ordinary commercial condenser is made from sheets of tin foil separated by mica or paraffined paper. Some manufacturers now have a process of placing a thin layer of tin foil upon one side of the paraffined paper forming a part of the paper itself. The condenser is then built up by placing several sheets of tin foil and waxed paper or the special paper mentioned upon each other and rolling or folding them into the commercial shapes. Alternate layers of the tin foil are connected and brought out of the terminals as shown in Fig. 11.

Condenser Connections.

By remembering how resistances connected in series and in parallel affect the total resistance and then applying just the opposite to condensers to obtain the total capacity there will be no trouble in remembering the rules of the condenser connections.

The capacity of condensers connected in series as shown in Fig. 12-A is

$$C = \frac{1}{\frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3} + \ldots} \qquad \text{eq. (16)}$$

When connected in parallel or multiple as in Fig. 12-B the capacity is

$$C = c_1 + c_2 + c_3 + \ldots \qquad \text{eq. (17)}$$

in which C is the total capacity and c_1, c_2, c_3, etc., are the capacities of the individual condensers connected.

For example, two 2 M. F. and one 4 M. F. condensers are connected in series. What is the combined capacity?

Solution: From eq. (16)
$c_1 = 2$, $c_2 = 2$ and $c_3 = 4$.

Then by substituting their values in equation 16

$$C = \frac{1}{\frac{1}{2} + \frac{1}{2} + \frac{1}{4}} = \frac{1}{5/4} = \frac{4}{5} = .8 \text{ M. F.}$$

If these same condensers had been connected in multiple, then from eq. (17) $C = 2 + 2 + 4 = 8$ M. F.

PROBLEMS.

EDITOR'S NOTE.—*If there is any question on any of these problems, write us; we will be glad to help you. Answers will be published next month.*

First Lesson.

1.—If a 25-watt tungsten lamp is operating on a 110-volt circuit, what current is passing through the lamp?

2.—When the power costs twelve cents per Kilowatt hour, what will it cost to burn the 25-watt lamp 10 hours?

3.—If 25-watt, 120-volt lamps were to be burned on 120-volt circuit for same length of time, what would be difference in the cost of this service and that in problem 2?

4.—When the lighting current in a building was 220 volts and only lamps with 110-volt rating were available, how would they be connected?

5.—What is the resistance in ohms of 25 and 40-watt lamps operating on 110-volt circuit?

Second Lesson.

6.—What is the loss in power in watts due to the transmission line copper loss if 10 horse-power is being furnished a customer, assuming it was delivered at 110 volts 1.000 feet from the power house and the line was of two wires, No. 4 B. & S. hard-drawn copper?

7.—What would the loss have been if the voltage was 220?

8.—How is this an argument in favor of high voltages for the transmission line when the line is long or when large amounts of power must be transmitted?

9.—This loss is manifested by the drop in voltage between the power house and the customer's end of the circuit, called line drop. This is required to overcome the resistance of the line. (a) What would be the voltage at the power house in the sixth problem above? (b) What in the seventh problem above?

10.—The commercial efficiency of any part of a plant is considered as the ratio of the output to the input at that load. What is the efficiency of the transmission line at the load mentioned in problem 6?

Third Lesson.

11.—What size wire with (a) rubber insulation and with (b) other insulation should be used, disregarding the voltage drop, for 20 incandescent lamps, each rated at 40 watts on 110 volts?

12.—What size for 10 lamps otherwise as above?

13.—What current carrying capacity must the wire have which is used in the winding of four relays connected in series and operating on 350 volts if two of them have a resistance of 100 ohms each, one 150 ohms and one 50 ohms, with line resistance of 25 ohms?

14.—If 25-watt lamps are operated on a 30-volt circuit, how does the current through them compare with that through 110-volt lamps rated at 25 watts?

15.—Assuming that the filaments in the two lamps in problem 14 are of the same material and length, how do their cross sections compare, taking into consideration their voltages and resistances?

16.—If the ordinary carbon lamps require about 3¼ watts per candlepower and the tungsten lamps 1½ watts per candlepower, how does the cost of current compare for the same intensity of illumination?

Fourth Lesson.

17.—What is the copper loss in a two-wire transmission line between points 4 miles distant if the size wire is No. 4 B. & S. hard-drawn copper carrying 100 amperes at 68 degrees F.?

18.—What would this loss amount to in one year if the average current was 25 per cent of the above, and with the power costing $0.06 per K. W. hr. to produce?

19.—What is the diameter of a wire in mils which measures 3/64 inch in diameter?

20.—What are some of the advantages in using paper insulated, lead covered cables for telephone and telegraph purposes?

21.—What is its great disadvantage in case it is installed out of doors and a crack develops in the lead sheath?

22.—What is the total conductivity of a multiple 110-volt circuit on which there are 10 forty watt and 1 twenty watt lamps, disregarding the resistance of the wiring and fixtures?

23.—What is the total current flowing in the circuit in problem 22?

24.—What is the combined resistance of the 11 lamps connected as in problem 22?

25.—If these same lamps were to be connected in series, what voltage would be required, omitting the 20-watt lamp?

26.—What would be the total current in the circuit when the lamps are connected in series as in 25?

Fifth Lesson.

27.—If one of the lamps connected as in problem 25 proved defective on account of a broken filament, how would this affect the series circuit?

28.—The temperature of a conductor is found by measurement to be 90 degrees F. What is its temperature C.? Show steps.

29.—What should the C. scale show when the F. scale reads 10 degrees below zero or —10 degrees F.?

30.—What important advantage is gained by using hard-drawn line wire instead of annealed? In what respect is annealed superior to hard-drawn?

31.—From the wire table find or determine the following for No. 10 B. & S. hard-drawn copper wire:

(*a*) Diameter in inches.
(*b*) Diameter in mils.
(*c*) Area in circular mils.
(*d*) Area in square inches.
(*e*) Weight per hundred feet (C').
(*f*) Weight per mile of metallic circuit.
(*g*) Resistance per 1,000 feet (M').
(*h*) Approximate breaking strength.
(*i*) Per cent elongation in one foot.

32.—(a) What size in N. B. S. gauge is nearest to No. 10 B. & S.? (b) What is their difference in area?

33.—How would the micrometer gauge be set for No. 8 B. W. G. copper wire?

Sixth Lesson.

34.—What is the unit of electrical pressure?

35.—What is the relation between the pressure and the current in a circuit?

36.—How does the current depend upon the resistance or does the resistance depend upon the current?

37.—State Ohm's law as you understand it.

38.—What is the cause of the loss of pressure in a pipe carrying a fluid such as water?

39.—How does the current leaving a generator compare with that returning to it?

40.—What is known as "line drop?"

41.—How does the "copper loss" vary in lines having the same resistance, but different current values?

42.—What current is flowing in a conductor having a resistance 0.15 ohms if it has a drop of 2 volts?

Seventh Lesson.

43.—Of what does the return conductor or feeder usually consist in a street railway system?

44.—Why is this objectionable from the standpoint of the company having underground conduit and cable systems in the neighborhood?

45.—What methods have been suggested to overcome this trouble in a practical way?

46.—What is the action taking place which causes the trouble in the underground system?

47.—If conductors having a resistance equivalent to 30 mi. of 19 B. & S. gauge cable are considered the limit of good telephone transmission, what length of No. 8 B. W. G. hard-drawn copper would be its equivalent from the resistance standpoint?

Eighth Lesson.

48.—If the voltmeter kick of a condenser having a capacity of 1 M. F. charged to 10 volts was 12.5 scale divisions when discharged, what is the capacity of another condenser charged by same battery and giving a throw of the needle or "kick" of 20 scale divisions?

49.—How do you account for the subsequent discharges from a condenser?

50.—(a) What amount of electricity would be required to charge a 2 M. F. condenser to a pressure of 1 volt? (b) To 5 volts?

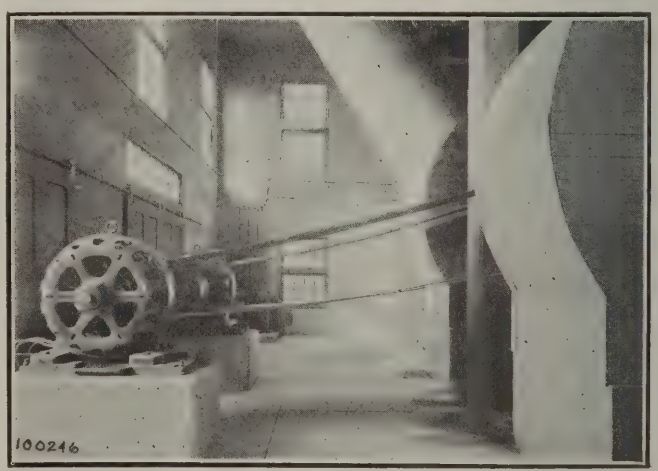
51.—What is the total capacity obtained by connecting in series two-5 M. F., one-1 M. F., and one-6 M. F. condensers?

52.—If these same condensers were to be connected in multiple, what will be the capacity?

53.—The rating of condensers is based upon their capacity when charged to a potential of 1 volt. What is the amount of electricity required to charge the condensers connected as in problem 52, if charged to a potential of 10 volts?

PRE-COOLING REFRIGERATOR FRUIT CARS.

The illustration shows one of two sets of two 7-foot Sirocco blowers driven by 75-h. p. Westinghouse motors which are used by the Pacific Fruit Express



Large Blowers with Motor Drive for Cooling Refrigerator Cars.

Co., Roseville, Cal., for pre-cooling fruit cars previous to filling their refrigerators with ice.

Air is drawn from cooling rooms, in which the temperature is kept at about 18° F. by direct expansion ammonia coils, and is forced into the cars, thus reducing their temperature and effecting a considerable saving in ice during transportation.

LESSON 18.

U. S. L. TYPE "C" EQUIPMENTS.

Type "C" equipments of the U. S. Light & Heating Company were placed on the market during 1910 and 1911. They all employ practically any of the Bliss generators and generator suspensions, lamp regulators and generator regulators as described below, the main difference between the various panels, "C" 5, "C" 6 and "C" 7 being in regard to the stop charge feature.

The Generator.

The generator is shown mounted on link suspension in Fig. 102. There are three types of generators supplied

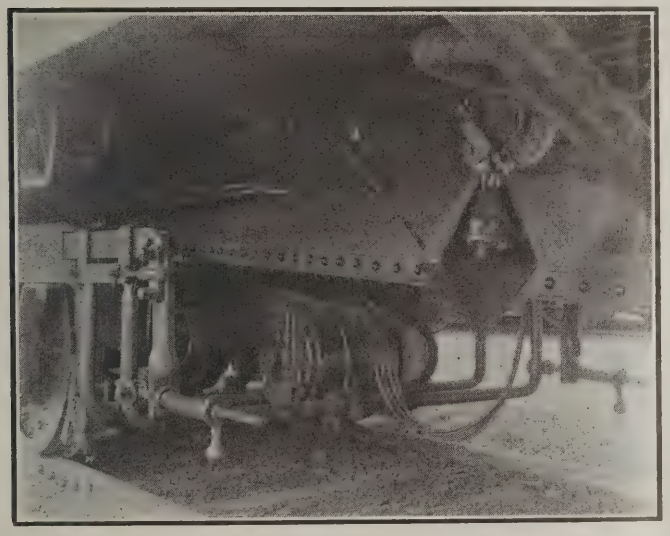


Fig. 102. The USL Generator with Link Suspension.

to meet the requirements of any particular class of service. Type "M" generator is made in four styles, for 30 to 40 volts only, and for 40 to 60 amperes. It is, therefore, rated at 1.6 and 2.4 k.w., respectively. The four styles of Type M, 1 and 2, each built for 40 and 60 amperes, are supported with long supporting lugs or feet, and are adapted for use on wooden trucks in connection with narrow suspensions. Types M-3 and M-4, 40 to 60 amperes machines, respectively, are provided with short supporting lugs or feet, and are designed particularly for use on steel trucks with cars having deep center sills with side suspensions.

The Type "O" generator is made in four styles, for 30 to 40 volts—60 amperes, and 60 to 80 volts—40 amperes. It is a larger machine than the Type "M" and operates at a lower cutting-in speed. It is rated at 2.4 and 3.2 k.w. Types O-1 and O-2 are provided with long supporting lugs, and Types O-3 and O-4 are provided with short supporting lugs, as explained above.

Pole Changer.

The pole changer in this equipment was of a very novel design, when first developed by W. L. Bliss, and applied to his earlier equipment in 1905-6. It has since, however, been applied to a large number of equipments, and is more or less common to car lighting men. An explanation of the principle of its operation, however, will be of interest and value to the men studying this course.

If you will refer to Lesson 2, published in March, 1912, it will help you in understanding this pole changer, for that lesson deals with the fundamental principles of generators. (If any of the boys have lost their copy of this lesson, a duplicate will be gladly forwarded upon request.)

The arrows in Fig. 14 indicate the flow of the magnetic lines through the generator poles, armature and frame, and also show the brush connection. In the Bliss generator, a small exciting current circulates through the field coils when the car is at rest. This maintains the generator fields always in the same direction. If the train moves in the opposite direction, from what it was when the generator was last operating, this would cause the generator to rotate in the opposite direction from formerly, and would tend to reverse the polarity delivered by the armature to the four brushes, as shown. In other words, the positive brushes would then be negative and the negative positive.

As soon as the generator begins to revolve in this reversed direction, however, the friction of the brushes on the commutator causes the entire brush mechanism to revolve 90 degrees. The positive brushes are thus moved around 90 degrees to the positions where the armature will deliver positive potential to them, and similarly the negative brushes are moved to a position where the armature delivers negative potential. This is a very simple and ingenious method of maintaining constant polarity, and is giving excellent results in service.

Suspension.

The suspension employed on most of the generators considered in this lesson is known as the parallel link type, as shown. This consists of two side bars, which pass through and are supported by the truck sill, as shown in Fig. 102. At the rear end these side bars are securely bolted to the truck sill. Two heavy "U" shaped links support the generator, and are bolted with cotter-pins to the saddle-irons which ride the side bars, as shown. These parallel links are held the same distance apart at the top by the spacing bar, through which the link bolts pass. The side bars are bent downward and twisted to provide a base for the generator tension springs one of which is placed on either side of the suspension.

Since the vertical distance between the pivoting point at the link bolts and the bottom of the generator feet is very large, the amount of rise or fall of the generator as it is moved backward or forward in bringing the belt tight, is small, so that the effect of the unbalanced weight of the generator in the off position is comparatively small.

The Automatic Switch.

The automatic switch is of the single vertical plunger type, with both series and shunt windings, as first applied in car-lighting service by Mr. Bliss in 1905. The operation of this automatic switch was explained in Lesson No. 10, November, 1912, so we will not discuss it further here.

There is a special feature in the switch, however, that must be described. It will be noticed upon referring to any of the wiring diagrams that there is a short circuiting contact made above the switch, which will be opened when the switch closes. This contact short circuits the

resistance unit "C," which, when the switch closes and this contact is raised, inserts this resistance "C" in series with the shunt-lifting coil of the switch. This automatically reduces the current flowing through this lifting coil after the switch is closed. This has the double benefit of reducing the heating of the coil and also providing that when the switch opens on slowing for a stop the reversed current through the series coil of the switch, will not be so large as where this feature is omitted. The switch is then opened with an arcing current of lower value, and the burning of the switch contacts is greatly reduced.

rent takes no part in the regulation of the equipment.

Charge Controlling Feature.

As the storage battery charges, its voltage will gradually rise, and the voltage of the generator will rise similarly, always keeping a little ahead of the battery voltage, this being necessary to force the charging current through the battery. When this voltage has risen to approximately 42 volts, the voltage coil of the taper charge device shown at the upper left-hand corner of Fig. 103 and Fig. 104, will be sufficiently energized to attract the iron vibrating reed shown above it in the wiring diagram, Fig. 103. The taper charge feature of the equipment is

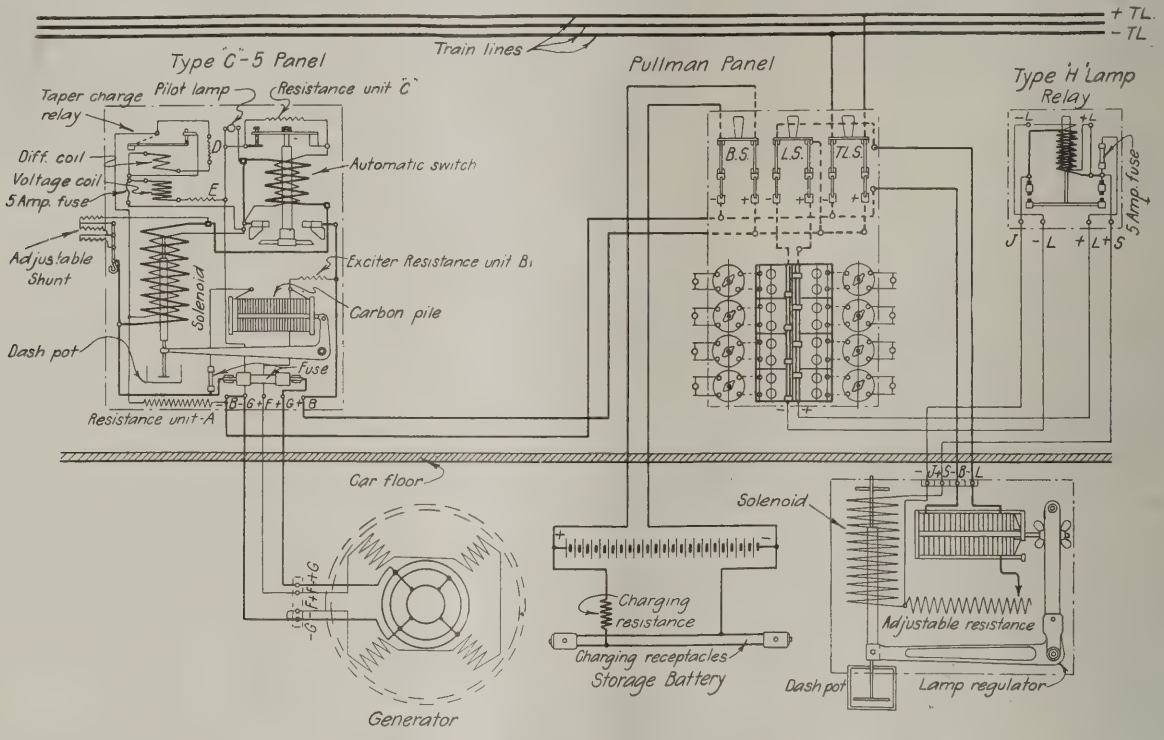


Fig. 103. Wiring Diagram of USL Equipment with C-5 Generator Regulator Panel.

Generator Regulator.

The generator regulator of the Type C equipments controls by varying the generator field current to compensate for rise or fall in train speed. This variable field resistance consists of a carbon pile, the pressure on which is controlled through a system of levers by the main regulating solenoid. As explained in previous lessons, if the pressure on this carbon pile is increased its resistance is decreased, and if the pressure is relieved somewhat the resistance of the pile is correspondingly increased. The increase of its resistance causes a decrease in the generator field current, hence a reduction of generator field voltage, and vice versa. It will be noted, upon referring to wiring diagram, Fig. 103, that the generator current feeds to the regulating panel at + G, thence through the main fuse to the main solenoid winding, where the current divides, most of it going through the regulating coil, but part being shunted around this coil by the adjustable shunt, as shown. These two currents unite at the other terminal of the solenoid and pass through the series winding of the automatic switch, through the switch contacts to the distribution panel, where it divides, supplying either battery or lamps, as desired. As more lamps are turned on, the battery current decreases so that the total load on the generator remains constant. The adjustable shunt feature, as mentioned above, is provided so that the current output may be adjusted to any value desired. This simply provides that more or less current, depending upon the setting of the shunt, is shunted around the solenoid, and this current then effective and the equipment controls substantially on a principle of constant voltage control until after the battery discharges at some stop and its voltage is reduced.

It will be noted upon reference to the wiring diagram that the main regulating solenoid has a shunt winding of fine wire inside the heavy series winding. This shunt winding is normally short circuited by the contact point of the taper charge relay, so that when the generator voltage is below 42 volts, there will be no current flowing through this winding. When the relay becomes operative near the end of the battery charge, however, and the iron reed begins vibrating, causing rapid momentary short circuits of the shunt winding, which will cause the current flowing through this coil to flutter slightly but the average value of this will be such as to keep the generator voltage constant at 42 volts. It should be understood that the magnetism of this shunt coil creates a certain number of "ampere turns" of magnetizing force, which simply replaces a similar number of ampere turns in the main series winding. This accordingly reduces the amount of current flowing through the series winding.

When the taper charge relay first becomes effective, the simmering of the contact reed is so slight as to be hardly noticeable. As the battery current begins to decrease, however, due to the fact that voltage is maintained about constant, the ampere turns in the series winding will decrease, and in order to maintain the same magnetic pull on the solenoid plunger, the ampere turns of the shunt solenoid correspondingly increase. The

reed of the taper charge relay then vibrates perceptibly and the percentage of the time the contact is open determines the magnitude of the current flowing through the shunt coil of the solenoid. As explained in Lesson 12, January, 1913, in connection with the Frost-Everett Regulator, the magnetic inductance of the main solenoid winding prevents the current in the solenoid from rising up to full value on the momentary impulses of current

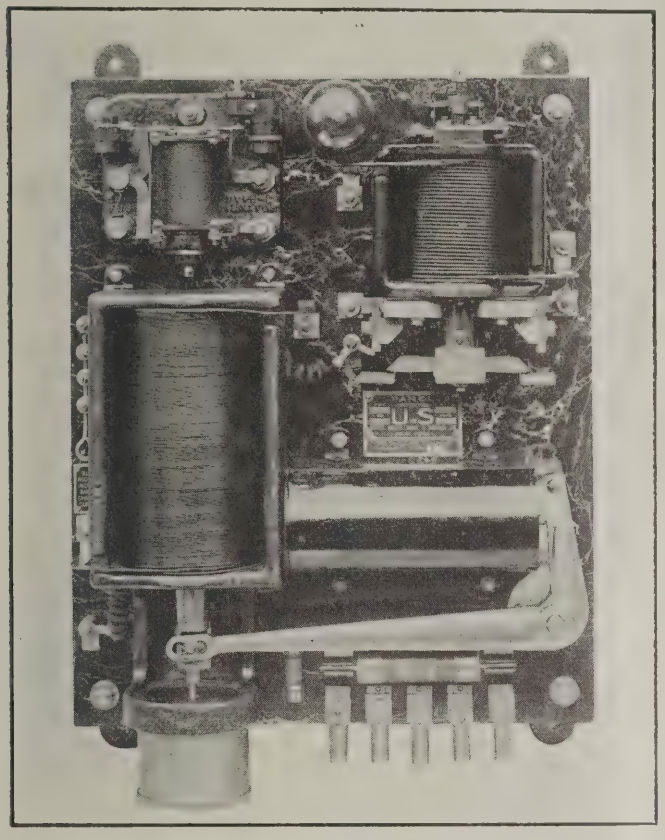


Fig. 104. C-5 Generator Regulator Panel.

flow on short circuit. The current through the shunt solenoid builds up slowly; and similarly when the tact short circuits the solenoid winding, the current does not drop at once to zero, but gradually decreases. The result of this is that with a rapid make and break of the contact in the relay, the current flowing through the solenoid simply flutters a little and neither falls off to zero nor rises to the full maximum value, which would flow in case the contact were held open permanently.

The differential coil of the relay simply serves to make the vibrations of the reed more rapid. If there were no differential coil at all, results similar in principle would be obtained, except that the fluctuation of current through the shunt winding of the solenoid would be so slow as to cause a surging of the plunger up and down, which would be undesirable. It will be noted that the differential coil is short circuited by the contact point of the relay in the very same manner as is the shunt winding of the main regulating solenoid. Resistance unit "A" which is in series with both the main shunt winding and the differential winding of the relay, is of 24 ohms resistance, so that even with the taper charge contact closed, and the shunt and differential coils short circuited for any time, the current is but slightly over an ampere. The resistance of the various coils in the panels are as follows:

PANEL "C-5"

	30 Volt		60 Volt	
A	Tube	20 Ohms	2-in. series	No. 20 w.
B	R29	50 Ohms	R-30	70 Ohms
C	R29	50 Ohms	R-32	140 Ohms
D	R29	50 Ohms	R-30	70 Ohms
E	R27	24 Ohms	R-32	140 Ohms

Lamp Regulator.

The main lamp regulator is somewhat similar in its construction and principles of operation to that described in Lesson No. 13, February, 1913. It consists of simply a pile of carbon blocks placed in series with the lamp circuit. The pressure on these blocks is controlled by a solenoid plunger with a system of levers, so as to adjust the resistance of the pile to such a value as to maintain the lamp voltage constant, irrespective of the voltage of the generator. The relay which controls the operation of this regulator, however, is entirely different from that mentioned above.

Type "H" Lamp Relay.

This relay has a vibrating contact which rapidly makes and breaks a short circuit across the solenoid of the lamp regulator. The percentage the total time contact is open determines the amount of current flowing through this solenoid, and hence, the magnetic pull on its plunger which causes the pressure on the carbon pile.

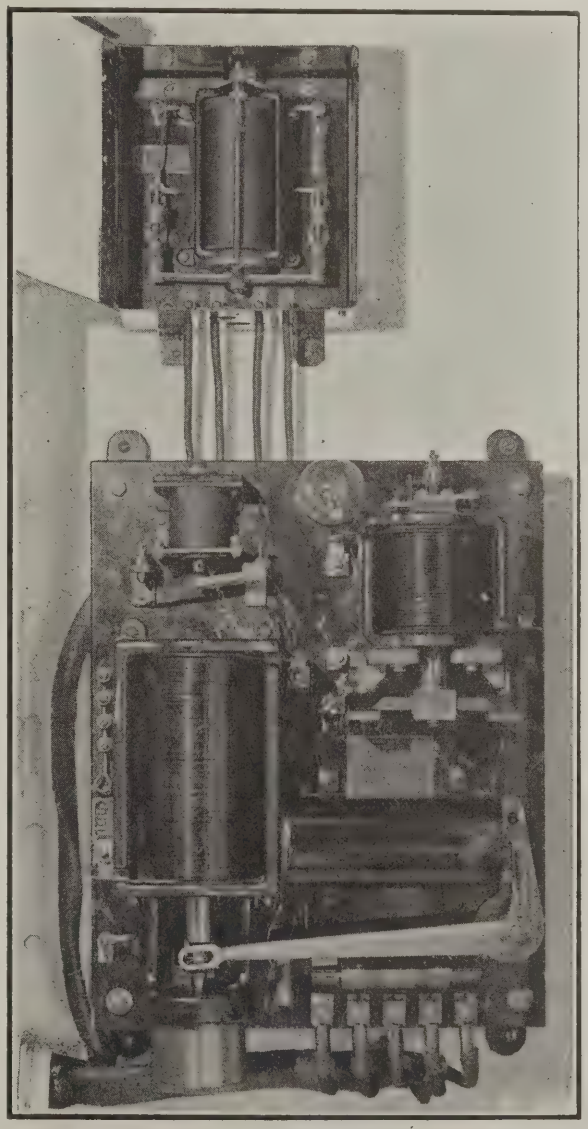


Fig. 105. C-6 Generator Panel with Type "H" Lamp Regulator Relay Above.

This relay is shown in the upper right-hand corner of the wiring diagram, Fig. 103, and also at the top of Fig. 105.

The type "H" relay consists of a compound wound solenoid, with plunger held upward by the pull of an adjustable spring not shown in the diagram. The shunt

winding of the solenoid is fed from the positive lamp terminal through the 5-ampere fuse, thence through the coil to the negative lamp terminal. An increase in lamp voltage above normal, for which this winding is designed, will pull the plunger downward into the coil, open the short circuiting contacts and allow the current to flow through the main solenoid for an instant. This will then pull up the plunger of the main solenoid, which, acting through the system of levers, will decrease the pressure on the lamp resistance carbons and by increasing the resistance, reduce the voltage on the lamp circuit. It will be noted from the wiring diagram, however, that the current which flows through the lamp regulator solenoid also passes through the differential series winding of the relay solenoid, so that just as soon as the short circuiting contacting is opened and current flows through the solenoid, the same current must pass through the series winding of the relay, and this immediately opposes the magnetism of the shunt winding and allows the springs to pull the plunger upward again, closing the short circuiting contact.

Instead of all this happening slowly, as we must explain it, the plunger with contact goes up and down rapidly; in fact, vibrates. The differential series winding of

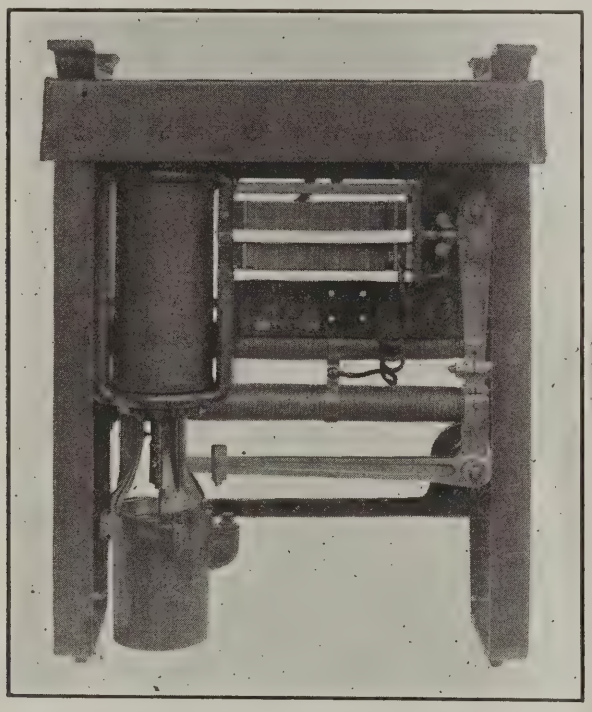


Fig. 106. Lamp Regulator, Mounted Below the Car.

the relay is employed for just this purpose of making the relay vibrate rapidly.

This make and break of the short circuit across the lamp regulator solenoid causes the average current to be adjusted to such a value as will provide for the correct pressure on the lamp resistance carbons. The principle of the operation of this relay and regulating is practically the same as we explained above in connection with the taper charge feature of the generator regulator.

Type C-6 Panel:

The Type C-6 panel, as shown in Fig. 108, is identical with the C-5 panel, except as regards the stop charge relay, shown in the upper left hand corner of Fig. 108. When the battery voltage rises to 42 volts, this will draw up the contact arm and close a circuit through the shunt winding on the main solenoid. The current which flows through this shunt winding will not be a pulsating current, as in the C-5 panel, but will be a steady flow since the contact of the relay is closed solid instead of vibrating, as in the C-5 panel. The shunt magnetism will then build up to a large value; in fact, so large as to entirely replace the magnetism of the series winding and pull the solenoid plunger up solid, greatly loosening the car-

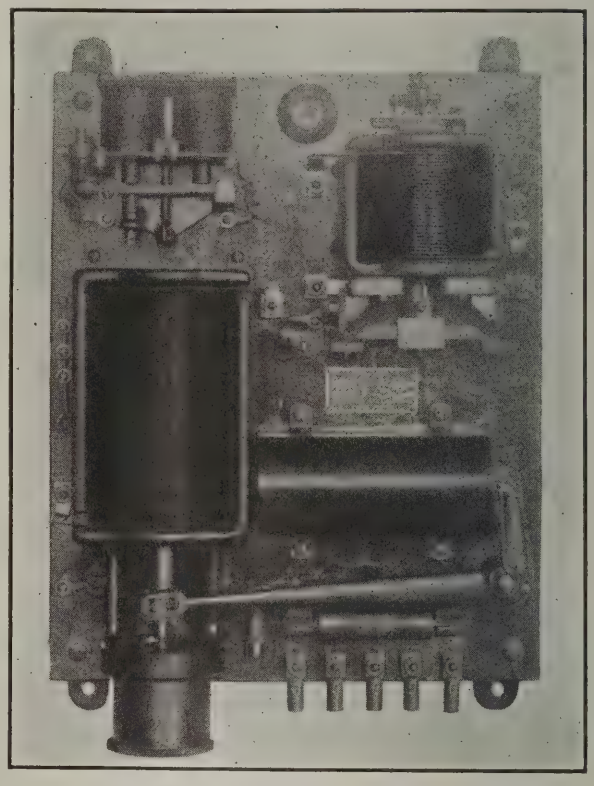


Fig. 107. Type C-7 Panel.

bon pile in the field circuit and thus killing the generator.

In order that this relay operate entirely satisfactorily, the battery must always come to a full charge at 42 volts with normal charging current flowing. As explained in previous lessons, however, the voltage of a storage bat-

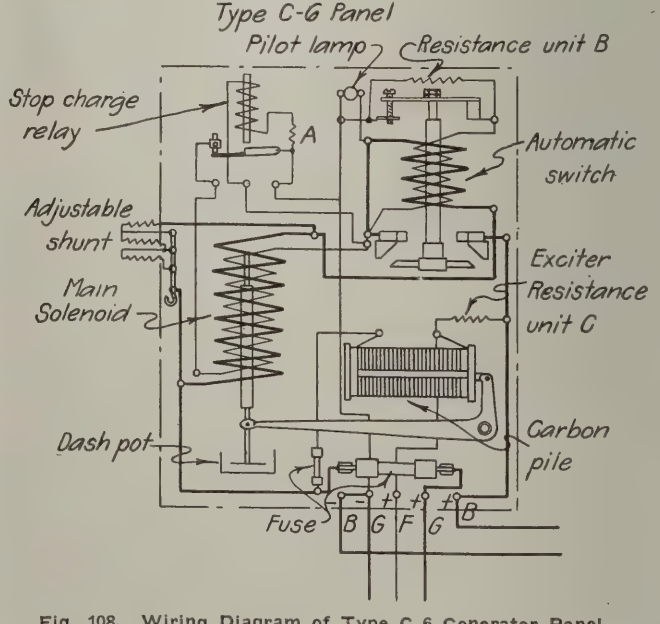


Fig. 108. Wiring Diagram of Type C-6 Generator Panel.

tery at the finish of charge may fluctuate anywhere from 38 volts to 48 volts, depending on temperature, charging rate gravity, etc., so this panel has been largely replaced by later types employing a combination voltage-

current regulator, as will be explained in an early issue.

PANEL "C-6"

		30 Volt		60 Volt	
A		0	Ohms	R-34	280 Ohms
B	R29	50	Ohms	R-32	140 Ohms
C	R30	70	Ohms	R-30	70 Ohms

Type C-7 Panel:

The Type C 7-panel is identical with the Type C 6-panel except that solenoid winding of the stop charge relay is divided into two coils, as shown in the upper

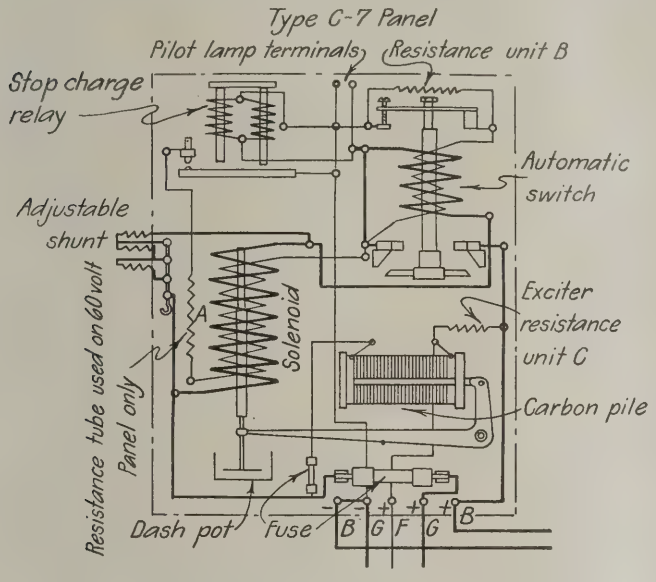


Fig. 109. Wiring Diagram of Type C-7 Generator Panel.

left hand corner of Fig. (—). On a 30-volt equipment these coils are connected in parallel, as shown, while on a 60-volt equipment they are connected in series.

PANEL "C-7"

		30 Volt		60 Volt	
A		0	0	Tube	27 Ohms
B	R29	50	Ohms	R 32	140 Ohms
C	R29	50	Ohms	R 30	70 Ohms
F	Tubes	13.3	Ohms	Tubes	53.2 Ohms

Practical Stunts

(We pay a dollar apiece for each practical stunt published. Send in your ideas.)

Rivets for Belt Fasteners.

To make the ordinary Crescent rivet clench right every time, put it in a vice and run a three-cornered file between the prongs of the lift a few times. This will give the points of the rivets a taper which will insure that they spread properly and clench when being driven into the belt.

I have found this stunt to be a good one and the results obtained fully warrant the additional work of filing the rivets.

J. A. Koch.

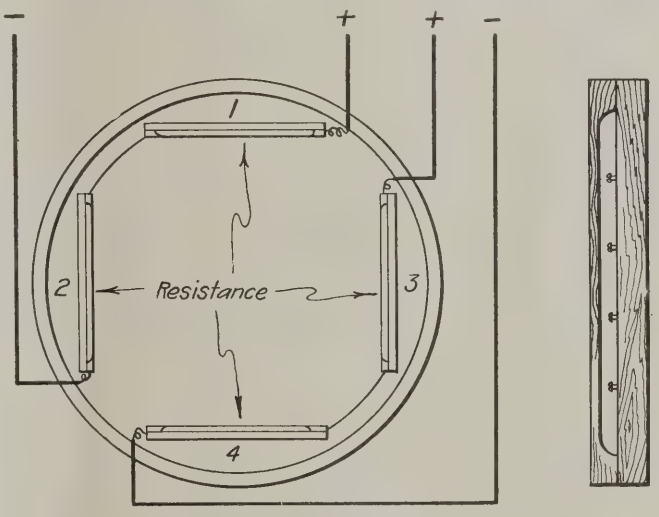
Heating of Battery Jar Covers.

It is very important that the battery jar covers be warmed so as to make them more or less flexible when applied, yet it very often occurs that steam is not able in battery houses. Under such conditions this practical stunt will be found of interest and value.

Four electric heater coils can be advantageously used, as shown in the accompanying illustration. Each of these coils consists of a small wooden frame 9x10 inches, upon which is mounted about 5½ ft. of No. 20 steel piano wire stretched between nails driven into the frame, as shown. These coils are then placed two in series on 110-volt circuit. It has been found under test that this heater will heat 30 gallons of water in 18 minutes, carrying a load of 70 to 75 amperes of current.

Since the acid with which the covers are soaked would attack the steel wire, it is necessary to add one pint of ammonia to 30 gallons of water, to neutralize the acid. This will have to be renewed occasionally.

Care should be taken when making taps to make



Plan View of Barrel with Heating Coils in Position.

them on the inside of the frame, as shown in the diagram, so that the strain on heating and cooling will not break the electric connection.

A wooden cover, as shown in the diagram, is placed over the face of the wires to protect them from injury when the covers are inserted or withdrawn. There is free space, however, for the warmed water to circulate upward back of each heater element.

H. A. Sunderland.

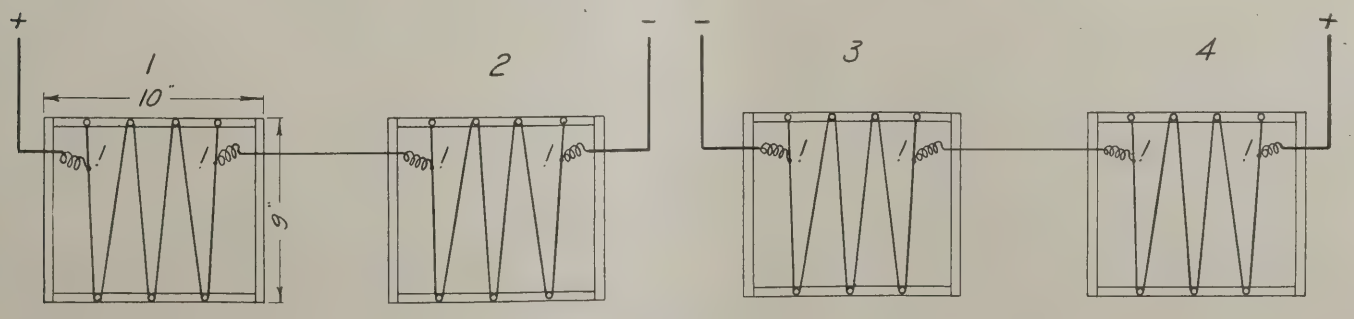


Diagram of Circuit Connections for Heating Coils.

Motor Talk No. 9

ALTERNATING CURRENT MOTORS. — (Continued.)

In Motor Talk No. 7 we considered some of the peculiarities of induction motors, with special reference to the three-phase motor. Two-phase motors are seldom used, but single-phase motors have now been developed to a high degree of efficiency, so we will give them our attention in this Talk.

It is well known that if the current passing through the field coils of a direct current motor should be reversed, or caused to flow through in the opposite direction, that the direction of rotation of the armature will be reversed. It is also well known that if the armature current is reversed the rotation is also reversed. But, it is equally well known that if the flow through *both* field and armature coils is reversed that the direction of rotation will *not* be changed. And, this is true regardless of how often or how rapidly the reversal takes place, even up to 25 or 60 or any number of times per second, as with alternating currents.

From this it would naturally seem that any direct current motor should operate on an alternating current circuit, if it is connected so the flow of current is reversed in both field and armature coils at the same instant. In the case of series connected motors this is true, for the current passes through both armature and field coils, one after the other, so that if any reversal takes place it affects both and the direction of rotation continues the same. This is the usual type of single phase motor used.

Shunt-wound motors do not run satisfactorily on alternating current circuits, in spite of the simultaneous reversal of both field and armature currents, because of the high self-induction of the field coils. That is, the current in each turn of wire tends to induce or create a flow of current in the adjoining turns which would flow in the opposite direction to the supply current. Hence, there is a resistance to the passage of the line current, a retarding effect which causes the field current to lag behind or be cut out of phase with the armature current.

This applies to both plain shunt and compound-wound motors, and is exaggerated by the large number of turns of fine wire in the shunt field coils. The result of this is to give a motor low efficiency and low power factor, and cause severe sparking at the brushes. This sparking is due to the fact that each armature coil has a large current induced in it momentarily as its commutator segment passes under the brushes. In other words, each coil becomes the secondary of a transformer for that instant.

In a previous Motor Talk we found that the armature of a polyphase motor was caused to rotate by the action of the rotating magnetic field of the motor, and how easy it is to do thus by bringing the various phase connections to different poles. But, with single-phase motors there is but one phase to deal with and the questions are often asked, "How can you get a rotating magnetic field with only one phase? How can a single-phase motor be made self-starting?"

Let us answer the first question by describing the Repulsion Motor, as that is a common form of single-phase motor. This motor has a commutator, of course, but the brushes are short circuited, connected together by copper rings. Then, as the coils come into place under the brushes they have current induced in them, as explained above, and are repelled by the alternating field current.

But, a single-phase motor has no starting torque when the armature is at rest, because the action of the field is balanced. So there must be some means provided for starting. After the motion once begins there is a turning force due to several actions. One of these is that the inductance of the armature causes the induced current in the coils to lag a little, gets out of phase with the field sufficiently to give the required magnetic repulsion. Hence, the name Repulsion Motor for this type of single-phase induction motors. In other words, a repulsion motor is really a transformer with the secondary coil pivoted so it can turn, has the secondary divided into several coils, each connected to a segment of the commutator, and with brushes to open and close the secondary coil circuits at the proper instants.

The second question may be answered in two ways, by saying that single-phase motors may be started by the "split-phase" or by the "repulsion" method. As to which method must be used will depend on the construction of the motor, so it is predetermined by the maker. Both systems are in extended use, so we will see what they are.

By "splitting the phase" we mean that we simply send the current through two parallel circuits, then place an inductance coil in one circuit in order to cause a lagging current to flow in that side, producing a slight difference in phase between the two sides of the circuit, and getting the equivalent of a two-phase motor for starting. Motors designed for starting by the split-phase method have two sets of field or stator windings, one for starting and one for running, with the inductance in the starting winding circuit to give the phase difference above mentioned. After the motor comes up to speed the starting winding is cut out of the circuit by a switch, usually automatic. Squirrel cage motors without commutators may be started by the split-phase method.

Starting by the repulsion method means that the motor is converted into a repulsion motor while starting and then the commutator segments are all short circuited or tied together for running. When starting, the brushes bear on the commutator in the usual way, and we have a repulsion motor, that is, a series motor on an A. C. circuit, with the brushes short circuited as previously described. After the armature comes up to speed, the commutator segments are all short circuited by a ring contact and the brushes lifted from the commutator. This is done automatically by a sort of governor.

The operating characteristics of single-phase motors are similar to those of poly-phase motors, as previously described in other Motor Talks, so we need not take room for that here. It might be well, however, to call attention to certain features of design which should be kept in mind when buying single-phase motors.

For instance, it has been stated that any series-wound D. C. motor will run on a single-phase circuit. That is true, but to get high efficiency the entire magnetic circuit, field as well as armature, should be laminated to prevent eddy currents in the cores and keep down the

heating and losses. This will require a larger sized motor for any given capacity than for D. C. operation.

Another thing is the effect of self-induction. To overcome this a higher voltage would be required than when run on a D. C. circuit, so motors are designed to operate at lower voltages by using higher amperages. Self-induction also causes a lagging current to flow and this reduces the power factor of the motor. These must be compensated for by designing the motor properly.

By increasing the number of coils on the armature the field flux may be reduced, and the turns required on the fields may be reduced by using small air gaps and high permeability pole piece cores. Self-induction is proportional to the frequency or cycles of the circuit, so it may be reduced and the power factor increased by getting motors for use on low frequency circuits whenever possible. In railway work 25 cycles is most common, but in shops 60 cycles is generally used.

(*The next Motor Talk will deal with Synchronous Motors.*)

Illumination of Railroad Shops

The many advantages of good illumination can be easily secured by the correct application of a few simple principles. These principles have been laid down many times before, nevertheless they are the important essentials and are frequently lost sight of before the lighting equipment is finally selected and installed. We should keep in mind, then, in solving shop lighting problems, the following points:

1. Shield the light source and keep it out of the range of vision.
2. Provide plenty of light.
3. Give the light proper direction.
4. See that the light is properly diffused.
5. Keep the system up to its original standard of efficiency.

All of the above are to be accomplished in the most economical way as regards current consumption, first cost of wiring and installing, and maintenance expense.

Interior of Work Shop.

A little careful planning and supervision will greatly simplify the working out of the lighting for seemingly complicated requirements. Select the proper size lamp for your needs; obtain reflectors that will most efficiently reflect the light and protect the lamp; determine with great care the location of the lighting units, their height and distance apart; and establish a regular schedule for cleaning and renewing of the equipment—you will then have accomplished practically all that is embodied in the five essentials above.

We say, locate the light units with great care. Emphasis is put upon this point, because it involves all of the five principles mentioned. Upon the location of units will depend intensity of the light, the directions from which the workman receives his illumination, the probability of the direct light of the lamps reaching the eyes of the worker, and the accessibility of the lamps and reflectors for purposes of upkeep.

Generally speaking, for shops and factories two classes of lighting are resorted to, i. e., the general system and localized system. In the one the lamps are mounted above the heads of the workmen giving

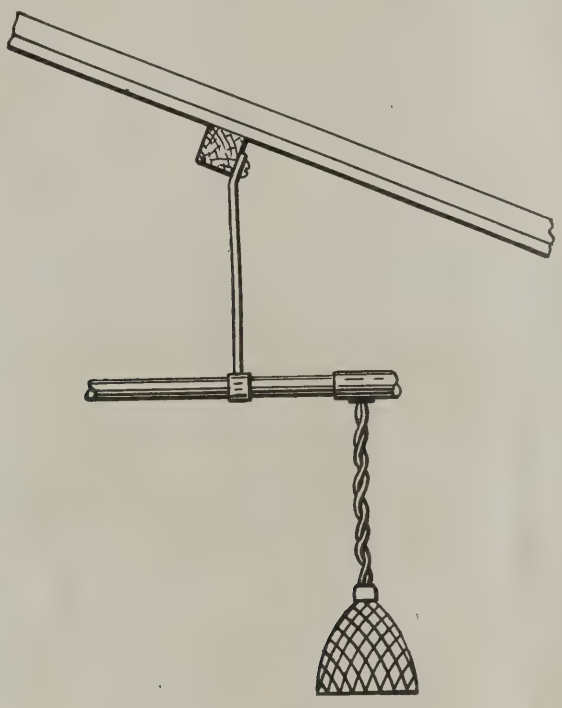
Interior of Machine Shop.

a uniform lighting in all parts of the room, and in the other case individual lamps on drop cords or brackets cause a strong light on the work, leaving the rest of the room in comparative darkness. Since there are very few instances in which local lighting is necessary, the general overhead system will fulfill most of the requirements of good lighting, and do it economically.

Of the many advantages of overhead system of lighting, the following are probably the most manifest. To begin with, the room with an absence of drop cords presents a very clean cut appearance, and in many cases an unobstructed view may be had from one end of the room to the other. This system also adds a cheerful appearance to the room, since the whole area is uniformly lighted. It also makes available for working purposes every square foot of floor space. The workman, for whom the lighting is really intended, receives the greatest benefit, the light reaches him from several directions, and the lamps being out of range of vision, add to his ocular comfort and eliminates the glare which is considered the most dangerous feature of modern illumination. The workman saves time in looking for tools and the annoyance of handling and adjusting the drop-cords is done away with. As a result of all this, he can turn out a better product with a small percentage of spoilage.

The satisfactory character of the results obtained

by the overhead system of lighting for shops, is shown by the illustrations. Attention is called to the evenness of lliumination, distinctness of detail, the clean cut appearance of the rooms, and lack of glare from light sources. The work room shown in figure No. 1 illustrates a most efficient use of every square foot of floor area, and the consequent necessity for an equally efficient lighting system. As a matter of engineering information we might say, that the reflectors are arranged on 10-foot centers in rows 11 feet 3 inches apart, the distance from the floor to the lamps is 11 feet, and the work tables are 32 inches high. Each lamp and reflector unit supplies eight men with adequate illumination an an expenditure in wattage of about .65 watts per square foot.



Method of Mounting Units.

For the description of the installation shown in figure 2, we quote the words of the engineer of the plant:

"This room is 116 feet long, 50 feet wide, and 13 feet high. The roof is inclined, so that it is 12 feet on one side and 14 feet on the other. We have 40 100-watt lamps in Bee Hive reflectors placed 10 feet centers, 9 feet above benches. We formerly lighted this shop with 80 55-watt lamps, and three 3½ ampere arc lamps, making a total of 5,555 watts formerly used against 4,000 watts now used,—a saving of 1,555 watts. Each bench and its table had three small 16 c. p. lamps. These aside from the annoyance due to handling were unsatisfactory in the lighting.

"There is not a single light now used other than the big units. This effects a very material saving, as each workman was compelled to adjust his lamps to every new position he assumed. This required time, and as each man had three lamps they were quite busy adjusting lights.

"There is a shop room immediately below this pattern shop room that is exactly the same dimensions. This room is lighted with a shallow bowl type of steel enameled reflector, same wattage as the pattern shop, same number of lamps. This room appeared to be very well lighted when first installed, but already there is complaint that they cannot see, due, I think, to the light not being properly applied. The direct rays or "glare" blinds the workman, and he tries to overcome it with an individual light. The workman suffers from the light, and does not know what is the matter with him."

Interior of Wood Shop.

As stated above, the placing of reflectors and lamps, has an important influence on the uniformity and direction of the light received by the workman. A symmetrical arrangement of units, as shown in figure 1, has the outlets spaced an equal distance apart. Each lamp and reflector takes care of a certain square area and the total result is a uniform illumination, that is, if the intensity of light were measured on the floor it would be nearly equal in all parts of the room. This symmetrical arrangement is ideal for shops or work rooms in which the character of the operations or work is much the same. In the case of the work room illustrated, it was necessary to provide a uniform arrangement of outlets, because of the close seating of the workmen. In figure 3 a more or less grouped arrangement of lamps has been adhered to, that is a number of reflectors are placed above a group of machines or benches, and the system of squares described above for figure 1, is not carried out. The arrangement in the case of figure 3 is somewhat affected by the presence of overhead shafting and belts. An advantage of this grouping is that it provides the greatest intensity of light where it is most wanted. This system is used extensively in shop lighting and is a good one to follow where a diversity of processes or operations are being carried on, which may require varying intensities of illumination.

In a general overhead lighting system the units should be placed well above the plane or work to be illuminated, and the most efficient reflectors be installed to throw the light down where it is needed. You will note that in each of the three cases illustrated here that the reflectors are placed at or near the ceiling, also that a flexible cord suspension has been provided. This practice is good, since the cord tends to absorb variations that would otherwise be transmitted to the lamp. Whether the roof is of saw tooth construction as in figure 1, of concrete, as in figure 6 or of mill construction as in figure 3, the same type of suspension can be used.

In each of the installations described the X-Ray Bee Hive reflector is installed. This reflector is made of corrugated glass in one piece with a coating of silver on the outside which is protected by an elastic

enamel backing. The inner surface of the reflector is given a fire glaze which makes the cleaning of the equipment a simple matter, since it is only necessary to wipe out the reflector with a dry cloth at regular intervals. The peculiar properties of the backing enamel used on this reflector, add to its permanent qualities and prevent any tarnishing or deterioration of the reflecting surface. This Bee Hive reflector was developed to meet the rigid requirements of modern reflector design, i. e., high efficiency in the reflection and distribution of light, and protection to the eye by the shielding of the light source.

General News and Personal Mention

A. C. MOORE.

Mr. A. C. Moore, active worker in and former president of the Railway Electric Supply Manufacturers' Association and well known to all car lighting men, was recently elected vice-president of the Safety Car Heating and Lighting Company, with headquarters at Chicago.

Mr. A. C. Moore.

Mr. Moore was born in Washington, D. C., 1880, and began working for the Safety company at the age of 19. In 1906 he became associated with the Western Steel Car and Foundry Co. and McCord & Co. In 1907 he returned to the Safety company as sales agent in the N. E. district, and was appointed manager of the N. W. district, with offices at Chicago, in 1908. He was appointed general manager in charge of the commercial interests of the company, with headquarters at New York in February, 1911, and on June 1, 1913, was elected vice-president with headquarters at Chicago, as above mentioned.

Reads like kind of a fairy tale, don't it? but there are few men who are the courteous, dignified, and consistent gentlemen that Mr. Moore is, * * * and we all wish you continued success, Mr. Moore.

RAILWAY UTILITY NOTES.

James H. Denton has been appointed eastern manager of the Railway Utility Company, Chicago, Ill., with offices in the Marbridge Building, New York, N. Y. Mr. Denton became connected with the Christensen Engineering Company in 1898 as sales engineer and remained with that company until 1906, after having served in various capacities, including that of chief engineer and general superintendent. Mr. Denton then became manager of the air-brake department of the Allis-Chalmers Company and in 1909 resigned from that company to enter the railway supply business for himself.

No, this isn't a special railroad edition of the Police Gazette—it's just a fleeting glimpse of the "Cabaret Twins" (Geo. Porter, Western Electric, and Joe Kuhns, Republic Rubber), who formed a pretty live part of the entertainment feature of the recent

The "Cabaret Twins."

banquet of the Western Railway Club—Who says "Nobody loves a fat man?"

Error in Last Month's Issue.

In the article entitled "Renewable Cartridge Fuses," in our June issue, there were two errors which occurred in the table:

Under the head of the last table "Knife Blade Type, 101-200," etc., should read "65-100." "Non-renewable" in the last table under "Types for Standard Fuses of the Non-renewable Type," the figures "50-10%" are given, whereas the correct discount is "50-10-10%." This special discount is given for fuse renewals and does not apply to new fuses.

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No Exposed Metal

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Ampere Capacity Stamped in Fibre

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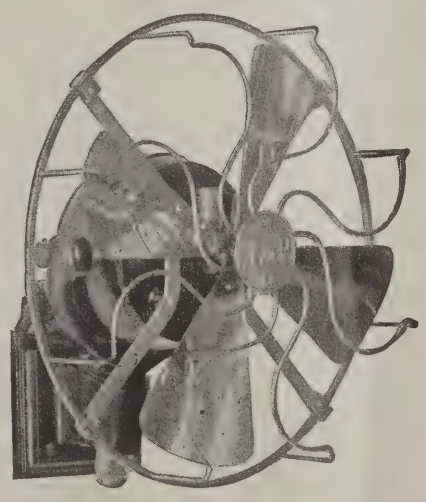
Approved by the National Board of Fire Underwriters



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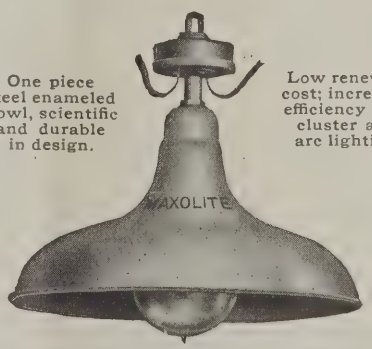
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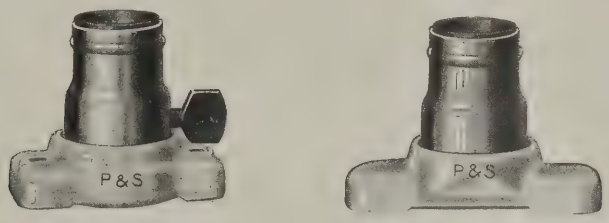
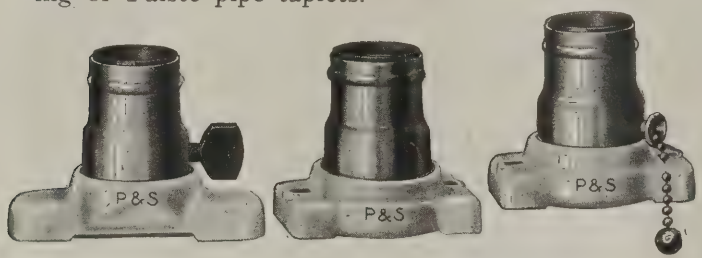
ADDITIONS TO P. & S. HANDY WIRING DEVICES.

P. & S. 461, 462 and 463, as shown in the accompanying illustrations, are key, keyless and pull type receptacles for use with condulet base.



New P & S Receptacle 461. Receptacle 462.

P. & S. 458, 459 and 460 are key, keyless and pull type receptacles resptively for use with wood molding or Paiste pipe taplets.



P & S Socket No. 458. Socket No. 459. Socket No. 460

P. & S. 452, 453 and 454 are key, keyless and pull receptacles for use in open wiring.

All of these nine receptacles embody the FLUTO style interchangeable shell. This FLUTO style inter-

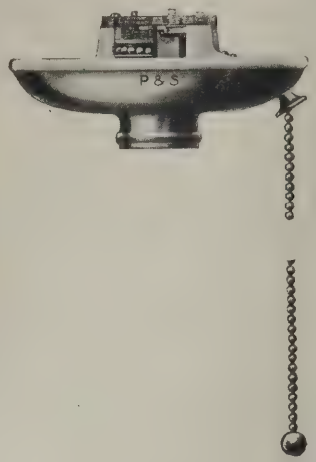
New P. & S. Socket No. 452. Socket No. 453. Socket No. 454.

changeable shell, used on these receptacles, is interchangeable with the entire P. & S. line of P. & S. FLUTO sockets and receptacles.

This company has also just placed on the market a new pull receptacle, P. & S. 428, designed exclusively for use on 4" boxes.

In the past it has been the practice to use on outlet boxes a pull receptacle which was primarily designed for use as a wall receptacle. Until this device was designed there was nothing exclusively made for use on outlet boxes.

The porcelain projecting ring insulates the metallic



New Chain Pull Receptacle No. 428.

shell from the box and from the ceiling; thereby permitting its use on metal ceilings.

It is regularly supplied with pull chain 18 inches long, but may be supplied to special order with pull chain of any length; or, if desired, with a silk cord in place of a chain.

ELECTRIC LIGHT FOR RAILWAY CARS.

This is the title of a pamphlet just issued by the available in battery houses. Under such conditions this U. S. Lighting and Heating Company, which shiuld be in the hands of every car lighting man. The booklet describes particularly the S-2 Panel and shows some interesting curves of the generator output.

This book will be sent to all the boys taking "The A. B. C. Lighting Coure," and any others can procure it upon postal request to the U. S. Lighting and Heating Company, Buffalo, New York.

NEW HIGH VOLTAGE SERIES CUT-OUT HANGER.

The Thompson Electric Company, of Cleveland, has just placed on the market a new high voltage series cut-out hanger which combines simplicity and reliability of operation with strength and excellent insulation qualities.

This new hanger is described in a small pamphlet just issued by the Thompson Electric Company, which will be forwarded upon request.

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H. G. WILLIAMS, Manager

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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The Sixth Annual Convention

On October 20th to 24th, the sixth annual convention of the Association of Railway Electrical Engineers will be held in the Hotel La Salle, Chicago. Each successive convention since the organization of the Association in 1908 has witnessed marked progress, and each has surpassed the one previous both in interest and value of the committee reports and papers presented, and in the number and character of the exhibits of the manufacturers. The past year has witnessed an especially marked activity on the part of the Association in postal car and coach illumination tests which are of a most fundamental and comprehensive nature. So the convention this year which will no doubt consider the results of these tests will be of an especially interesting and instructive nature.

The entire nineteenth floor of the Hotel La Salle will be used for exhibit purposes, the meetings of the Association being held in a large parlor on the floor immediately below. The usual entertainment features are being planned and as many of the various committees have been particularly active this year, it looks as if this convention is going to be the best yet.

Railway Car Ventilation

The problem of railway car ventilation is to provide clean fresh air in sufficient quantity and at the proper temperature, free from all cinders, dust and smoke. There is probably no other ventilating problem, except possibly that of the diving bell, in which the number of cubic feet of air per person is so small as that in a railway car. To make the problem more difficult the ordinary conditions of railway operation involve the production of dust from the road bed and cinders and smoke from the locomotive.

The construction of the modern passenger car with double window construction throughout largely eliminates the leakage ventilation of air through the windows incident to the train passing through the surrounding air at high speed, so that where an inadequate ventilating system is provided the effect is very soon noticeable.

Much has been done in the past few years in an effort to provide a more or less comprehensive system of car ventilation involving both exhaust and intake, and in one case an air washing system as well. It is now fully recognized by the best authorities that simply supplying an exhausting system is hardly adequate, for where the source of intake is not controlled, air will be drawn into the car through dusty vestibules and other unsanitary places. The ventilating system installed on the private car of President Baer of the "Reading," described in the *Railway Electrical Engineer* of June, 1913, provides for both exhaust and intake features. Moreover, motor driven blower sets located in both the exhaust and intake ventilators provide adequate ventilation whether the car is in motion or at rest. In this system cinders, snow and water are separated from the air taken into the ventilator and the air entering the car passes from the intake blower through a duct leading back through the car wall where it exhausts at certain intervals over the heating coils near the floor line. Here the air is heated before it enters the breathing zone of the passengers. The exhumed air is then gradually drawn upward by the action of the exhaust ventilators and passes out through them. A continual motion of fresh air from the floor line through the breathing zone to the car ceiling is then provided. This is, without any question, far superior to the drafty dilution method of the deck sash ventilation which, if it works at all, simply allows cold air to tumble down on the heads of the passengers.

No doubt the next few years will see the successful application of a practical air filtering or air washing system which will remove all smoke and dust from the air taken into the car. As described in the January, 1912, issue of the *Railway Electrical Engineer* an air washing system was installed on the Sante Fe "De Luxe Special." Although this system contained certain features which prevented its entirely satisfactory operation, the fundamental principle of washing the air as it enters the car and removing all cinders and smoke is excellent. Without doubt some of the experience gained in connection with this system will be used to advantage in future developments.

There does not seem to be any definite criterion by which one can determine whether or not a car is

properly ventilated. The carbon dioxide content, although an indication of the contamination of the air, cannot be taken as a measure of the excellence or lack of ventilation. As a matter of fact, an overheated car, high humidity or lack of air motion may be more instrumental in giving the effect of bad air or stuffiness in the car than the actual amount of carbon dioxide, or the lack of oxygen. "Still" air is usually bad air, and a "Stuffy" room or car is usually found to be one in which the air is motionless.

Electric fans for agitating the air are the solution of this part of the problem, and there should not be simply one or two per car, but six or eight in order to provide sufficient motion of air within the car, and these fans should not be taken down and stored away for the winter when the frost comes; they should be operated all winter long. It is a well recognized fact that many of the "Winter diseases," particularly those affecting the throat and lungs, are the direct result of improper ventilation.

With a large percentage of the cars electric lighted, motor driven blower ventilating sets and agitating fans may be installed which will provide adequate ventilation whether the car is in motion or at rest, and the next few years will no doubt see a continued activity and more successful development in this line.

Ventilation of the I. C. Railway Sun Parlor Cars

The Illinois Central Railroad has recently placed into service some new sun parlor cars to be used on their Florida winter trains. These cars include some novel designs in both the lighting, ventilation and general car construction features which will be of interest. The observation platform is entirely inclosed with plate glass, and two exhaust ventilators with a large indirect lighting unit are installed on the platform as shown in the accompanying diagram Fig. —.

Although the ventilating system of these cars is somewhat similar to that described in the *Railwoy Electrical Engineer* for June, 1913, this is the first application of such an installation to regular passenger traffic cars. A motor driven blower set is installed in a locker in one of the toilet rooms. The door of this blower locker is a tight fit so as to prevent the leakage of air from the intake line and a Garland intake ventilator as shown in plan view in Fig. — and in elevation in Fig. — is installed on the roof of the car over the blower locker. As the train passes through the surrounding air at high speed, the air will enter the ventilator as shown by the arrows in Fig. —, and striking against the baffle plate across the face of the ventilator will be deflected backward into the ventilator and pass downward through one of the two air intake ducts to the blower. This intake ventilator is similar in design to the standard Garland Ventilator except that a baffle plate is placed across the face of the ventilator, and a dividing partition is provided as shown. The baffle plate clears the car roof by about 1 in. so that any snow, rain or cinders which are carried into the ventilator will drain off. There is also another drain at the bottom of the air intake duct. This air intake duct is divided into two parts, one of which connects to one-half of the intake ventilator and the other to the other half. Only one-half of the ventilator operates at a time, but since these are identical in design the ventilator will operate with equal efficiency in either direction.

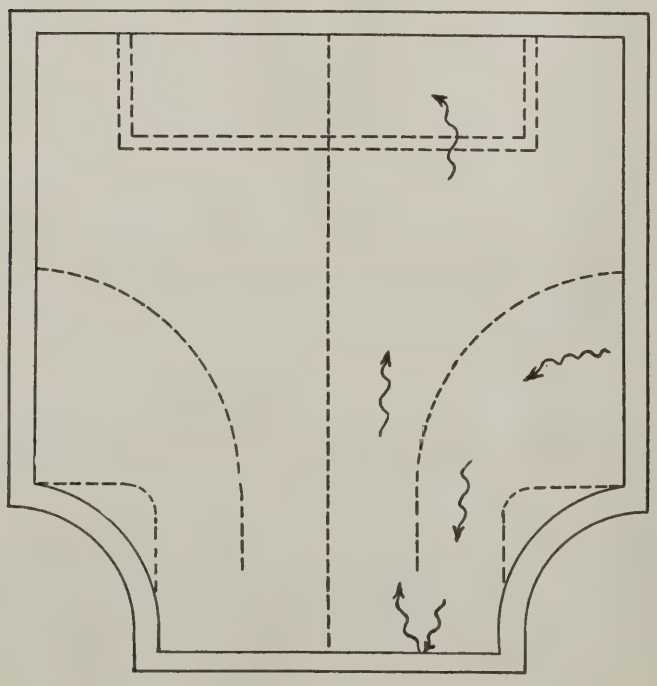


Fig. 1. Showing Action of Intake Ventilator

Fig. 2. Interior of Observation Compartment

The motor blower set is operated at all times that ventilation is required, whether the train is at rest or in motion. When standing still air is drawn through the intake system by the blower alone, and when in motion the action of the intake ventilator considerably increases the amount of air taken into the car. This passes from the intake duct into the blower

locker, thence through the blower to the ventilating air ducts located near the floor line of the car. One of these is located above the heating coils, and one behind the heating coils. One side of this duct is perforated with five rows of ⅛ in. holes at 1 in. spacing, extending for the entire length of the car. This permits of a gradual leakage of the air from the ventilating duct into the car body, but as this air passes over the heating coils, it will be heated to proper tem-

Fig. 3. Interior of Smoking Room

perature in the winter time. At no place however does it enter at sufficient velocity to give the effect of draft.

This warm fresh air will then slowly rise due to the fact that it is warmer than the other air in the room, and also due to the action of the exhaust ventilators above. It will then gradually rise, passing through the breathing zone of the passengers, to the car ceiling and be drawn out through the exhaust ventilators above.

An Anemometer test of the blower set operating when the car was at rest indicated a velocity of air motion of 32,000 ft. per hour, an equivalent of 6,400 cubic ft. of air per hour. With the train traveling at high speed this intake would undoubtedly be greatly increased, but even under standing conditions there was a constant flow of air into the car from the ventilating duct perforations which was perceptible. The speed of this air motion, however, was so slight, due to the large surface area of the duct that it is impossible to take anemometer readings. But it appeared that the ventilation at the extreme end of the

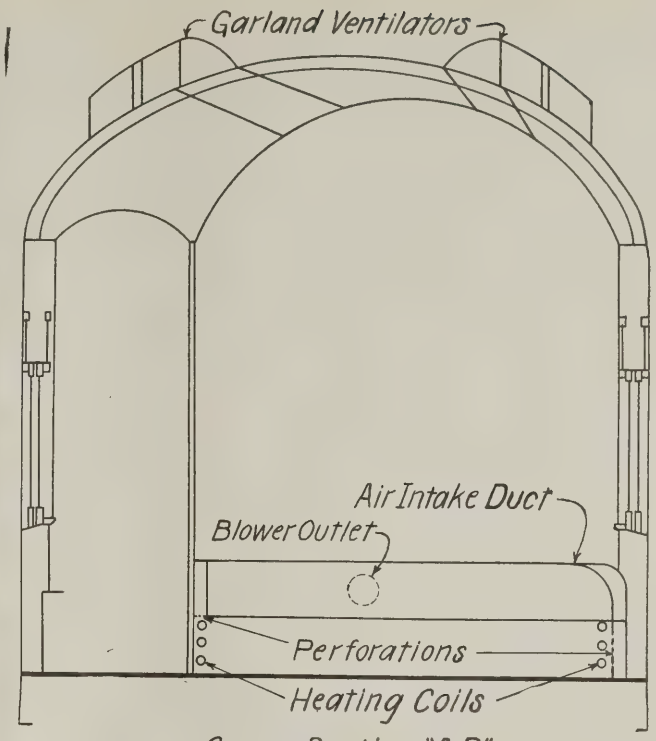


Fig. 4. Section of Car Showing Intake Ventilator

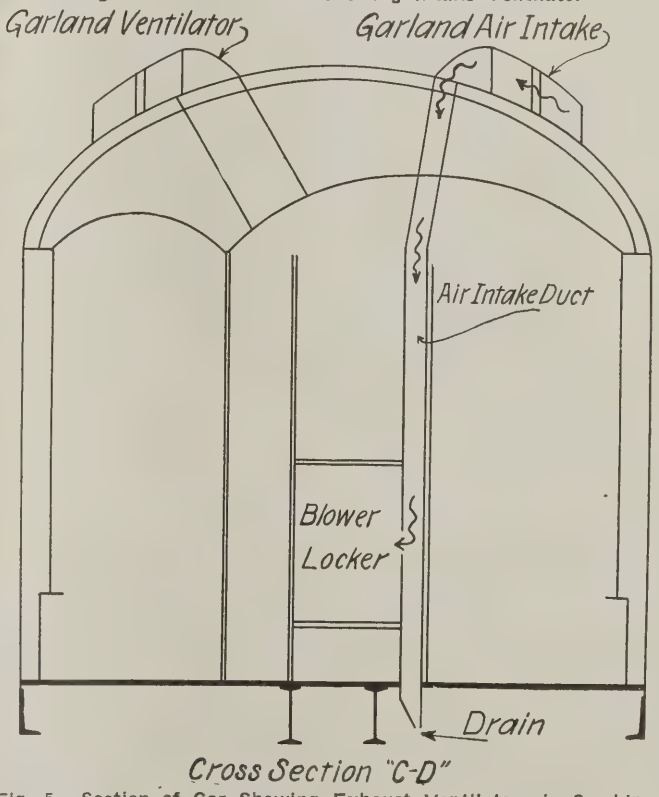


Fig. 5. Section of Car Showing Exhaust Ventilators in Smoking Room

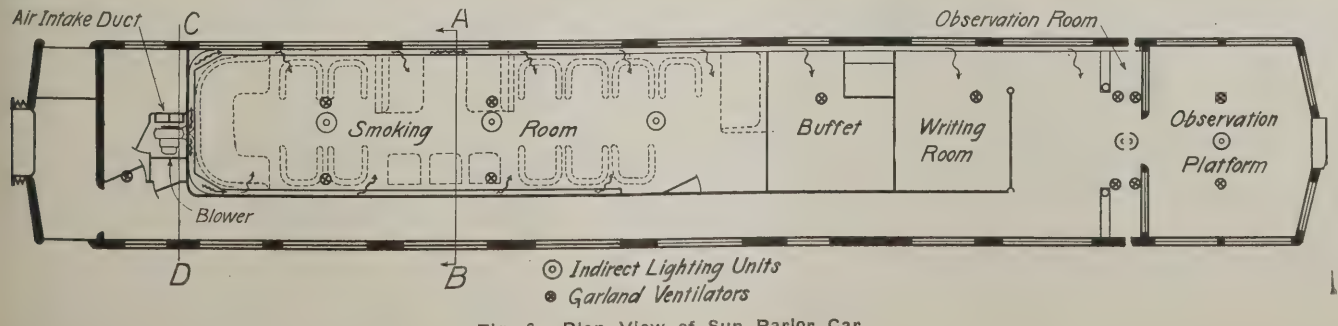


Fig. 6. Plan View of Sun Parlor Car

observation room was fully as strong as that in the smoking room nearer the blower.

These cars are equipped with indirect lighting fixtures of the "Alexalite" type throughout as shown in accompanying illustrations. The car ceiling is finished in light cream so as to provide a good reflecting surface for the indirect lighting system, and the balance of the finish is in light mahogany.

Ventilation of Postal Cars

The standard specifications for the government postal cars recently prepared by representatives of the government mail service and various railroads interested, has done much to stimulate the interest in the subject of postal car ventilation, and indirectly ventilation of other types of cars.

The construction of the standard postal car, with the letter cases and bag racks in the center of the car, and storage portions at each end, lends itself admirably to a simple yet effective system of ventilation. By installing intake ventilators at each end of the car and exhaust ventilators in the center of the car, there will be a constant circulation of air as shown in the accompanying diagrams Fig. — and Fig. —.

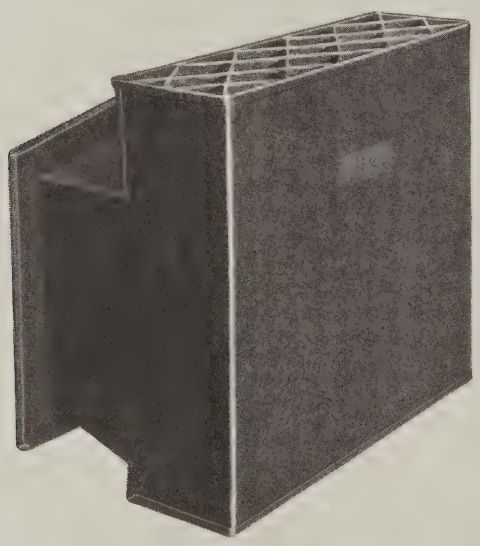


Fig. 1. View of Honeycomb Ventilator

Most of the work done by the mail clerks is at the letter cases and bag racks, located in the center of the car; only a small proportion of the time being spent in the storage section at each end of the car. Moreover the character of the work in the storage portion is of such a vigorous nature that the cold air from the intake ventilators above is not objectionable. This cold air, received from the intake ventilators is heavier than the warm air so circulates downward to the floor line as indicated by the arrows. Here it is heated by the heating coils of the car and gradually drawn to the center of the car by the exhaust ventilators. Fresh warmed air is then supplied the mail clerks at the letter cases at all times, and the exhumed air gradually passes upward and is drawn out of the car by the exhaust ventilators.

A vertical heating coil at each end of the letter case section prevents any direct draft of unheated air coming upon the mail clerks as they stand at the case.

The accompanying diagrams illustrate a novel postal car ventilating system as designed for the new postal cars for the Great Northern. The exhaust ventilators are of a new type., known as the Utility honeycomb ventilator. This ventilator is practically T shaped with both top and bottom open. These openings are subdivided by diagonal partitions into small flues, and the passage of the air over the top and bottom edges of these flues, due either to train motion or wind from any direction, creates a whirling motion in the air which draws the air outward from the car through these small flues at a considerable velocity.

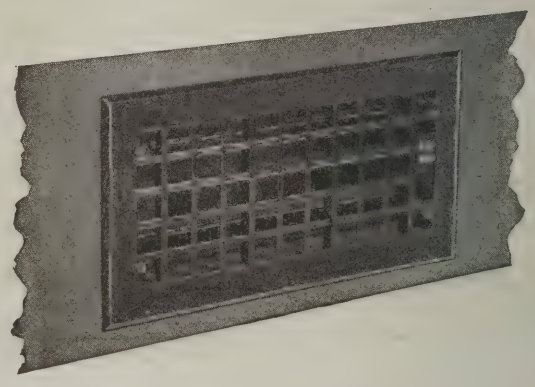


Fig. 2. Register Used in Place of Deck Sash

The modification of the standard side deck intake and exhaust ventilators for use on turtle back roof cars have been designed as shown in Fig. — and Fig. —. These operate on the same principle as the standard types.

The operation of the air intake ventilator is clearly shown diagramatically in Fig. —. The curved surface of the bottom, and the inclined vane on the forward end of the ventilator create a throat through which the air passes at high velocity. Upon passing

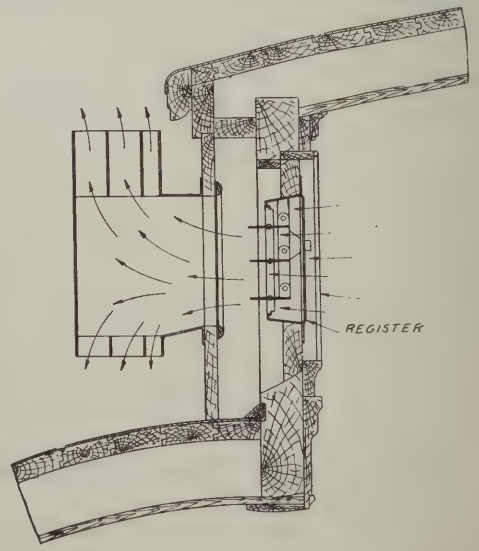


Fig. 3. Showing Position of Exhaust Ventilator

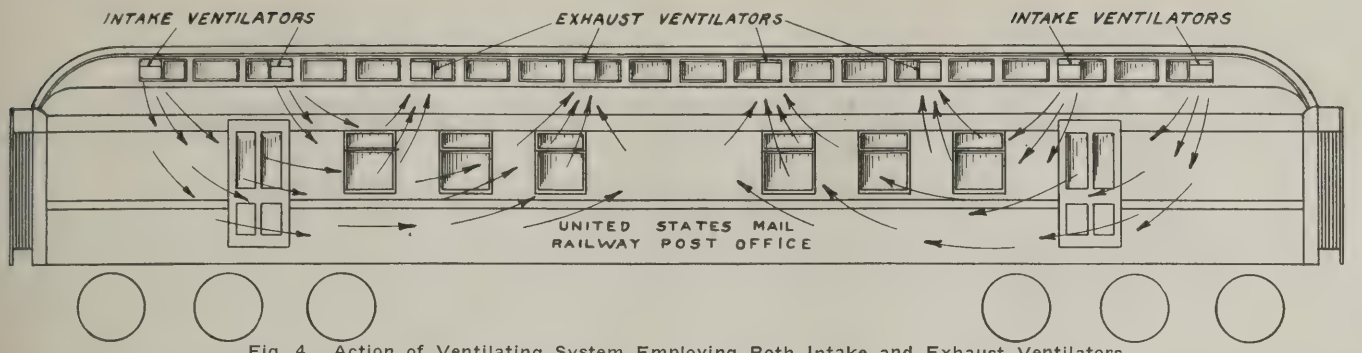


Fig. 4. Action of Ventilating System Employing Both Intake and Exhaust Ventilators

Fig. 5. The Honeycomb Ventilator Installed on a Coach

this throat however it enters a larger chamber and the velocity of the air greatly reduces. As is well known, when the velocity of either a current of air or water is greatly diminished, any matter being carried in suspension is immediately precipitated. This fact, together with the high speed of dust and cinders upon entering the ventilator cause the dust and cinders to be thrown to the rear plate of the ventilator

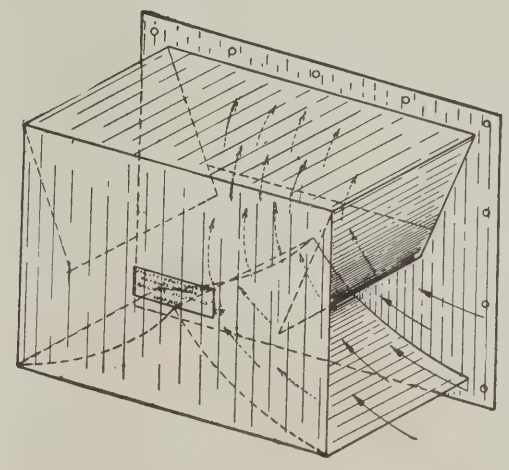


Fig. 7. Intake Ventilator for Monitor Type Roof

instead of turning to the side and entering the car with the air. They are thus carried out through the rear opening and only clean air enters the car. It will be seen that both ends of the intakes are alike and the action is the same regardless of the direction of car travel.

The round jet type ventilator is also shown in-

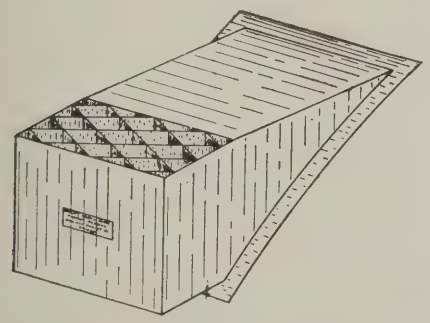


Fig. 6. Modification of Honeycomb Ventilator for Turtle-back Roof Cars

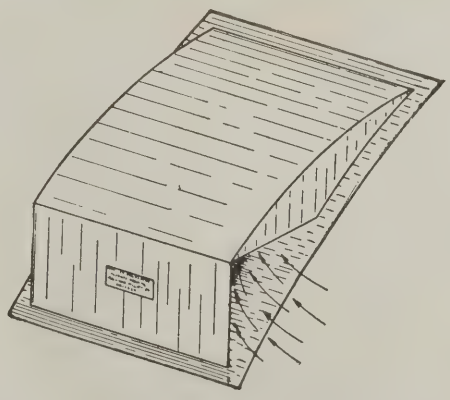


Fig. 8. Intake Ventilator for Turtle-back Roof

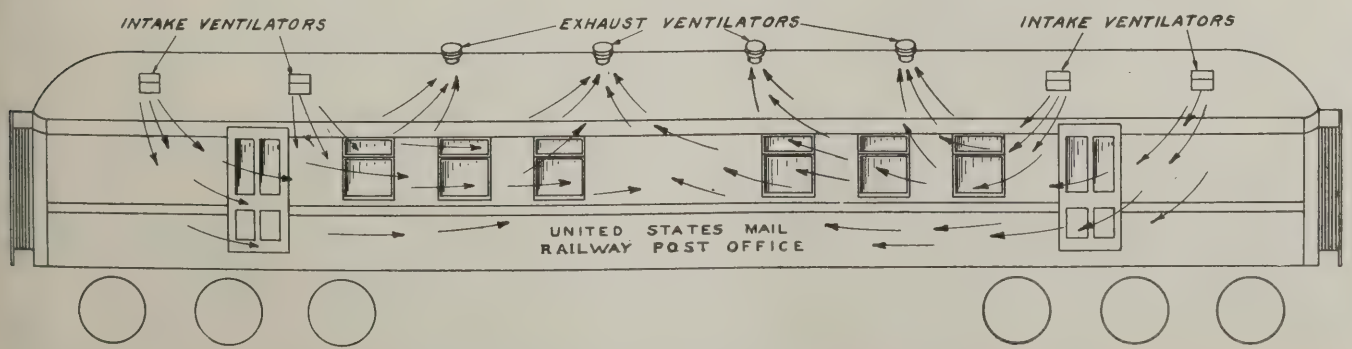


Fig. 9. Ventilating System as Installed on Turtle-back Roof Postal Cars

Fig. 10. Coach Equipped with Round Jet Type Ventilators

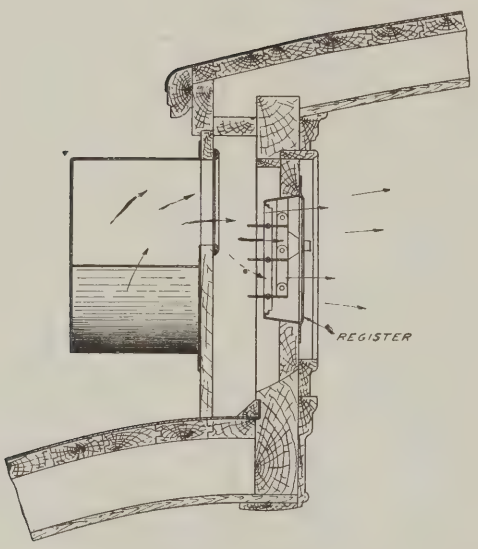


Fig. 11. Showing Action Through Intake and Register

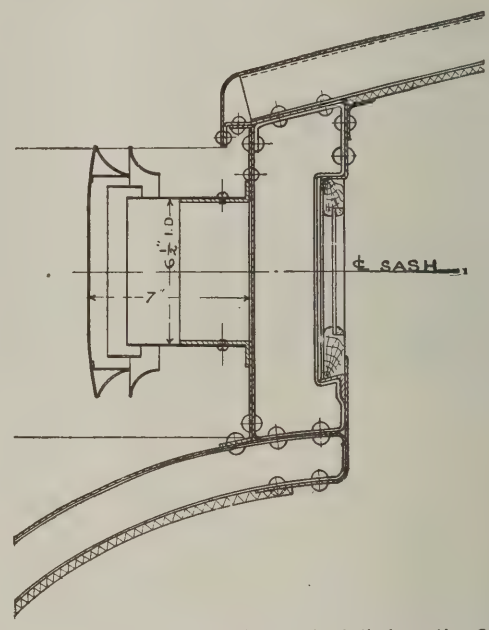


Fig. 14. Round Jet Type Ventilator as Installed on the C. B. & Q. Ry.

stalled on one of the postal cars. This can usually be installed in any service, as well as the honeycomb type. The action of this ventilator is clearly shown in Fig. 13. The curved surface of the top deflects the air downward between it and the outer ring. This is also curved in such a manner as to create a jet with remarkable power of suction which draws the air

Fig. 12. Round Jet Ventilator

from the interior of the car in large quantity. The efficiency of a jet depends upon the design of its converging curved surfaces, and this ventilator has been developed after considerable amount of experimentation. From an observation of the sectional diagram it is evident that no rain, snow or cinders can enter the car, whether the car be in motion or at rest, and whatever the direction of the wind be. Results of a series of tests made by Robert W. Hunt & Co., and the Chicago, Milwaukee & St. Paul Railway are given as follows:

HONEYCOMB VENTILATOR.

10 miles	6,000	cubic ft. per hour
20 "	12,000	" " " "
30 "	18,000	" " " "

ROUND JET VENTILATOR.

10 miles	4,800	cubic ft. per hour
20 "	10,000	" " " "
30 "	15,000	" " " "

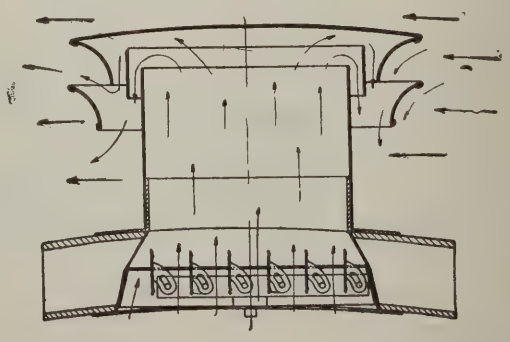


Fig. 13. Showing Action of a Side Wind on Round Jet Ventilator

Report of Committee on Lighting of Railroad Crossing Subways, Chicago

A Report Submitted to the General Managers' Association of Chicago by a Special Subway Lighting Committee

Historical.

A meeting was called by representatives of the Lake Shore & Michigan Southern Railway in the office of the Resident Engineer, La Salle Street Depot, on the morning of July 6th, 1911. The following railroads were represented:

H. C. Meloy, Supervisor Electrical Appliances, L. S. & M. S. Ry.
F. H. Schmit, Attorney, L. S. & M. S. Ry.
Frank Roblin, Electrician, C. R. I. & P. R. R.
C. J. Causland, Chief Electrician, Penna. R. R.
P. T. Dunn, Master Mechanic, Penna. R. R.
A. J. Farrelly, Electrical Engineer, C. & N. W. Ry.
L. B. Abbott, Electrician, C. & R. I. R. R.

The reason for calling this meeting was that the Lake Shore & Michigan Southern Railway had been called upon from time to time to install a system of incandescent lighting in subways under new elevations in the City of Chicago, and also to install a more satisfactory lighting in some of the subways under old elevations. After considerable discussion as to the methods of installing and maintaining the incandescent system as requested by the City, and also as to whether the Railway Companies should or should not light the subways, the question was brought up as to whether a decision had yet been rendered by the Supreme Court in the case of the City of Chicago vs. the Pennsylvania Railroad Company relative to lighting subways under tracks of the above Railroad Company. After ascertaining that no decision had been rendered it was suggested that the members of the Committee call upon Mr. L. E. McGann, Commissioner of Public Works and ascertain if the City would consider holding in abeyance the question of subway lighting until such time as a decision might be rendered by the Supreme Court in the case above mentioned.

On the afternoon of July 6th, 1911, this Committee called upon Mr. McGann, by appointment, to discuss the matter. The entire subject was discussed in its various aspects. Mr. McGann, after consulting with Mayor Harrison, advised the Committee that they would take no further action until a decision was rendered.

It was then suggested by the Committee that it might be a good plan to have a Commission on subway lighting appointed by the Mayor, to consist of representatives of the City Electrical Department and representatives of the Electrical Departments of all the railroads in Chicago in any way interested in subway lighting. Mr. McGann submitted this suggestion to the Mayor, who approved of same and advised the Committee that he would appoint such a Commission.

In July, 1911, the Mayor requested the managements of the various railroads interested to appoint representatives to serve on this Commission. In compliance with this request the following gentlemen were appointed by the various railroads:

Frank Roblin, Electrician, C. R. I. & P. Ry.
E. A. Bull, Chief Electrician, C. J. Ry.
H. C. Meloy, Supervisor Electrical Appliances, L. S. & M. S. Ry.
C. R. Gilman, Chief Electrician, C. M. & St. P. Ry.
E. D. Hubbard, Electrical Foreman, Grand Trunk Ry.
H. A. Gardiner, Electrical Engineer, C. B. & Q. R. R.
A. J. Farrelly, Electrical Engineer, C. & N. W. Ry.
L. B. Abbott, Electrician, C. & W. I. R. R.
E. W. Jansen, Electrical Engineer, I. C. R. R.
A. L. Chapin, Asst. Electrical Engr., I. C. R. R.
P. T. Dunn, Master Mechanic, Penna. Co.
C. C. Wright, Electrical Engineer, Penna. Co.
L. M. Gazin, Chief Electrician, A. T. & S. F. Ry.
C. E. Taylor, Chief Electrician, M. C. R. R.
G. R. Shirk, Chief Electrician, C. G. W. R. R.

REPORT OF TEST BY COMMITTEE.

Object of Tests.

The object of the tests here reported upon was twofold:

1. To determine the possible advantage of using reflectors with the lamps, instead of bare lamps, and to determine the most satisfactory type of reflector.
2. To determine the approximate number of square feet which could be covered by a single light unit with sufficiently satisfactory illumination results.

General Requirements.

The requirements of subway lighting may be summed up under six heads, as follows:

1. Sufficient illumination must be provided on the sidewalk and street so that pedestrians and drivers can see to avoid high flagstones, ruts, pools of water or any small obstructions. This means that the light units must throw a sufficient quantity of light down upon the sidewalks and street in a vertical or nearly vertical direction. Light rays emitted by the light units at angles above 45 degrees to the vertical strike the street in such an inefficient direction that they have little value in illuminating the street surface.

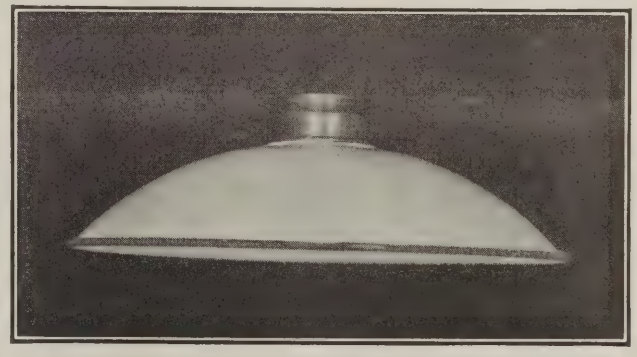


Fig. 1. Shallow Bowl Reflector Tested.

2. Sufficient light must be thrown on the vertical surface of large objects so that the character of such objects can be easily seen. For instance, it is desirable that a pedestrian be able to see the features and apprehend the general appearance of other pedestrians at as great a distance as possible. This means that the light units must throw out a sufficient quantity of light at wide angles, above 45 degrees, to adequately illuminate vertical surfaces. Light thrown down upon the street or sidewalks, at angles less than 45 degrees will have little value in illuminating vertical surfaces or in permitting one to distinguish the character of approaching objects.

3. Intensely dark shadows of considerable area, cast by supporting pillars or other interior features of the subway must be avoided. In any event, no shadows must be permitted which are at once suffi-

ciently large and sufficiently dark to permit of a person with evil intent lurking in them. This avoidance of objectionable shadows can only be accomplished by the proper placing of the light units. With the employment of one light unit to not more than every 800 square feet, seriously objectionable shadows can be avoided, providing the light units are properly

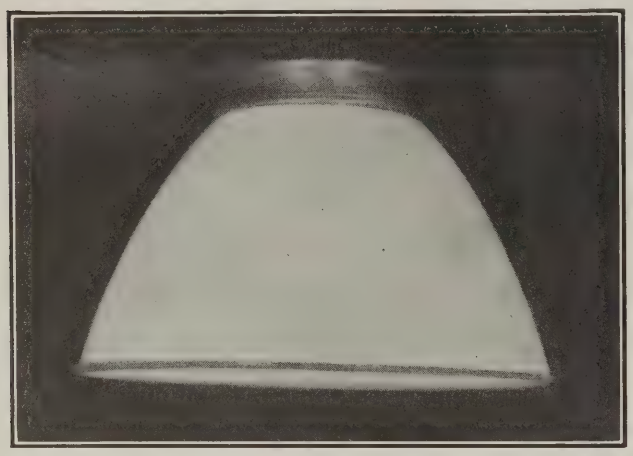


Fig. 2. Deep Bowl Reflector Tested.

located. It is strongly recommended that the location of light units in all subways be laid out by a thoroughly competent illuminating engineer.

4. The character of the light units must be such as not to throw a partially blinding light into the eye, thus decreasing the power of the eye to see. While a bare incandescent lamp cuts down the capacity of the eye to see far less than an arc lamp, it nevertheless decreases the capacity of the eye to see to a very serious degree. Any light thrown into the eye by the light unit within 25 degrees with the line of vision decreases the capacity of the eye to see. This consideration indicates that just as little light as possible should be emitted by the light unit above the angle of 65 degrees with the vertical.

5. The character of the light units should be such as to avoid producing ocular discomfort when one is passing through the subway. This means that the eye should be shielded as much as possible from the rays from the bare lamp.

6. The system should give adequate illumination with minimum expenditure of energy. This means, first of all, that an efficient light source, such as the tungsten lamp, should be used. Second, the light generated by the light source should be thrown in those directions where it will be useful, not allowed to go upward to the roof of the subway where it will be lost. This, of course, is accomplished by the use of reflectors. Third, while adequate illumination must be insured, care should be taken to avoid such excessive illumination as would waste the light with-

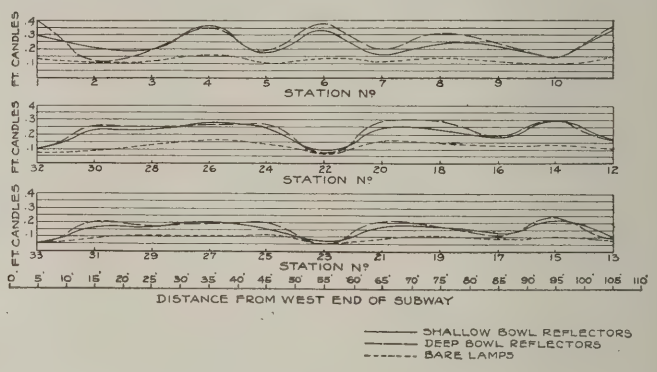


Fig. 5. Horizontal Illumination Tests, 400 Ft. Spacing (See Fig. 3).

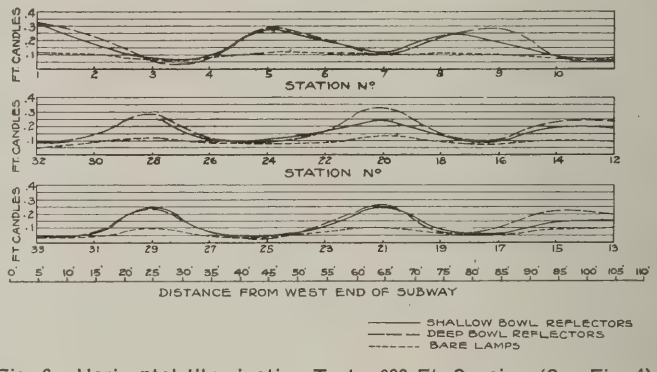


Fig. 6. Horizontal Illumination Tests, 600 Ft. Spacing (See Fig. 4).

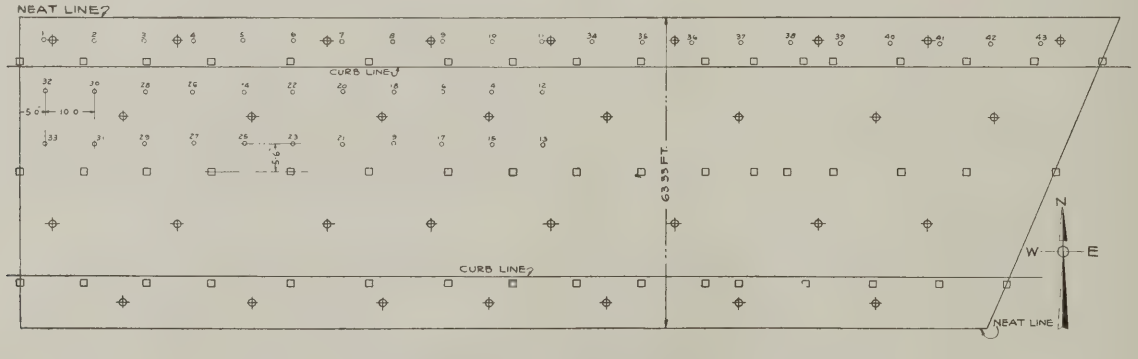


Fig. 3. Layout of Subway with Test Stations 400 Ft. Spacing.

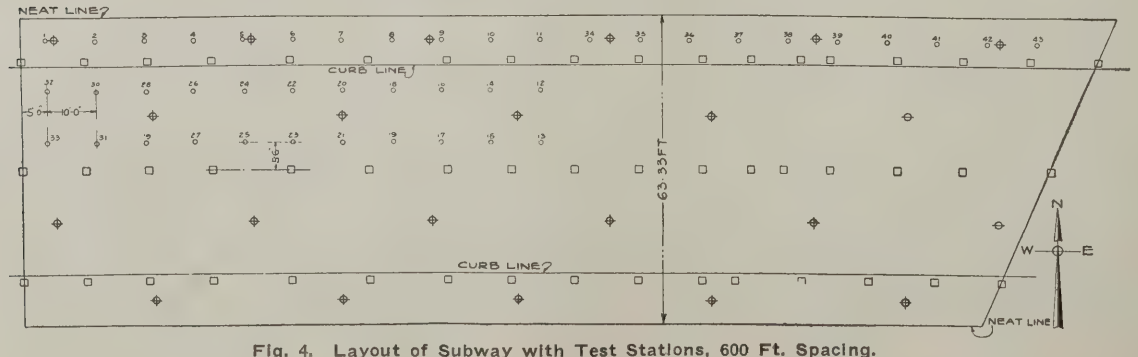


Fig. 4. Layout of Subway with Test Stations, 600 Ft. Spacing.

out adequate return in improved conditions of service.

It will be noted that some of the above requirements are partially contradictory. For instance, the better the vertical illumination which is provided (paragraph 2), the more light will be thrown into the eye, resulting in decreased clearness of vision (paragraph 4) and more or less discomfort (paragraph 5). The requirements expressed in paragraphs 1, 4, 5 and 6 all work in the same direction. The requirement expressed in paragraph 2 is, however, a very important requirement and works in exactly the opposite direction. It was kept constantly in

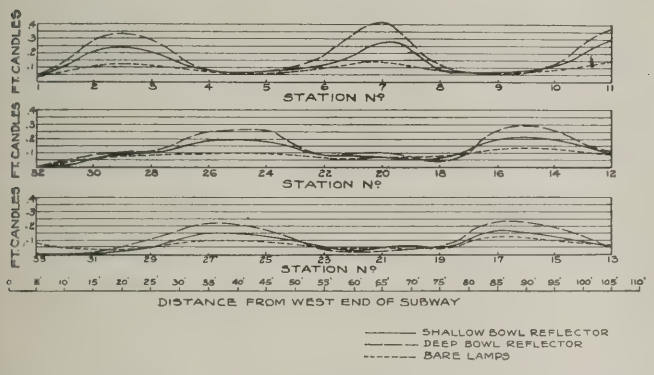


Fig. 7. Horizontal Illumination Tests, 800 Ft. Spacing (See Fig. 8).

mind that the tests should furnish sufficient data to permit the correct balance to be struck between the conflicting requirements.

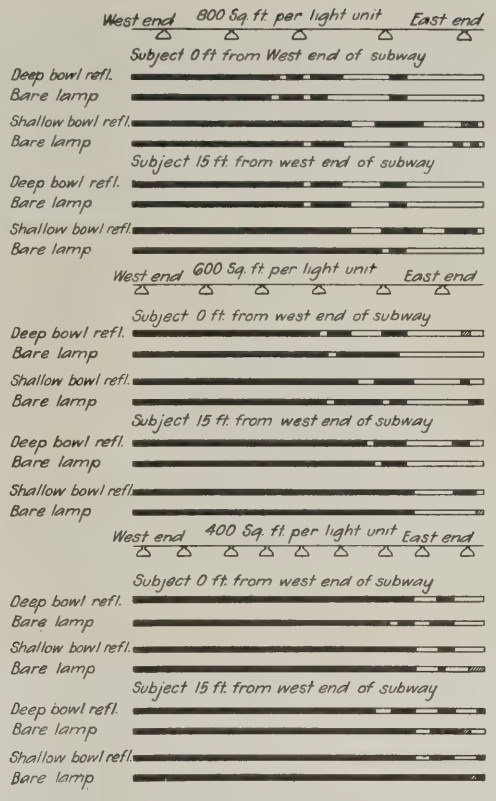

West end 800 Sq. ft. per light unit East end
Subject 0 ft from West end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
West end 600 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
West end 400 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp

Fig. 10. Graphical Summary Visual Efficiency Tests. With H. C. Meloy, Subject.

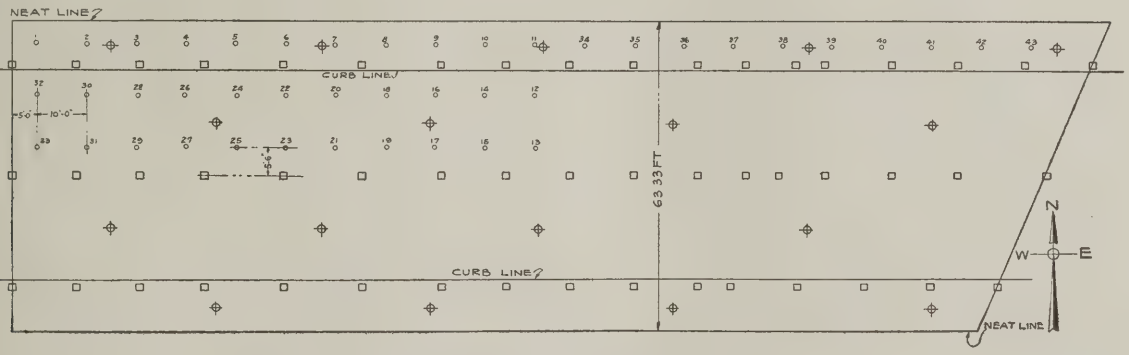


Fig. 8. Layout of Subway with Test Stations, 800 Ft. Spacing.

Systems Tested.

On account of its relative freedom from operating troubles and failures in service, of its high efficiency, of its convenience in properly maintaining, and of its availability in small sizes permitting the light to be properly distributed throughout the subway, the incandescent lamp was considered unquestionably the most satisfactory unit for the service here under consideration.

On account of the danger of breakage with any other material, it was considered that any reflectors used should properly be of metal. On account of the deterioration to which other types of metal reflectors are liable in out-of-door service, it was considered that the metal reflector used should be of the enameled reflector type.

For obvious reasons, the bare lamp constituted one type of light unit tested. Two types of reflectors, the deep bowl and the shallow bowl, were tested. It was realized that the deep bowl reflector would best meet the requirements expressed above, under the heading of General Requirements, in paragraphs

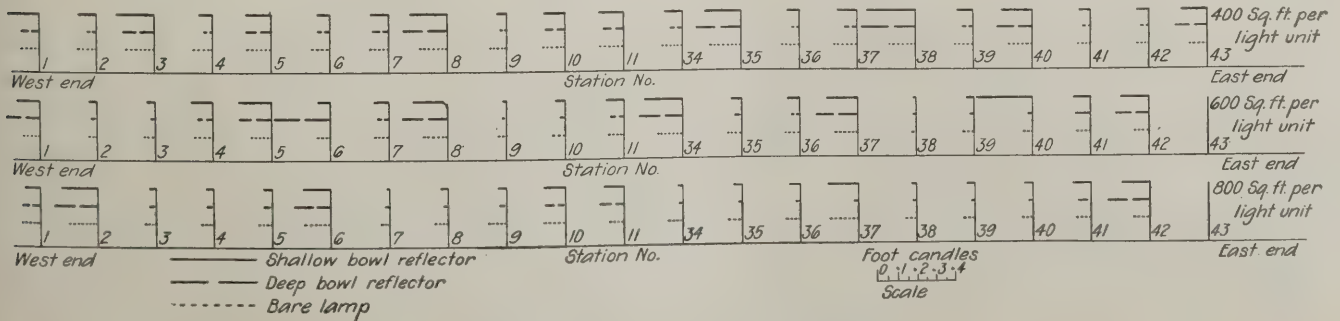


Fig. 9. Graphical Summary of Vertical Illumination Tests.

1, 4, 5 and 6. The shallow bowl, however, would much better meet the requirements expressed above in paragraph 2 and would fairly well meet the requirements expressed above in paragraphs 1 and 6. The shallow bowl really represents a condition intermediate between the deep bowl and the bare lamp.

Photographs of the types of unit used are given in Figs. 1 and 2.

All three types of units were installed on each of three different bases—namely, one unit every 400

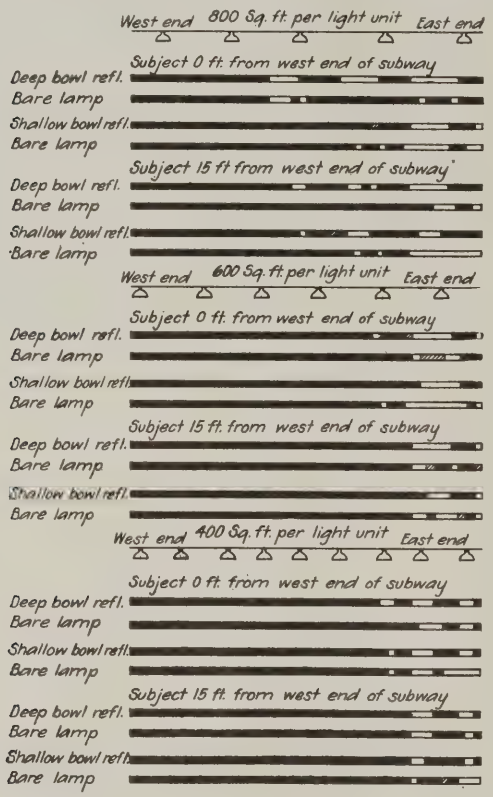

West end 800 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
West end 600 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
West end 400 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp

Fig. 11. Graphical Summary Visual Efficiency Tests, With G. R. Lindsay, Subject.

square feet, one unit every 600 square feet and one unit every 800 square feet.

General Method of Tests.

Tests were of two kinds. First, the illumination on the vertical plane and on the horizontal plane was determined by a series of illumination tests, the well-known and almost universally used Sharpe-Miller illuminometer being employed. Second, a series of visual efficiency tests were conducted. In these visual efficiency tests, Snellen letters, the well-known type of letters used on the cards employed by oculists in testing eyes, were employed. The particular letters chosen were E and F, of a size which should be distinguished by the normal eye by daylight at a distnace of 200 feet. The experimenter started at one end of the subway and gradually approached the object who stood at the other. The experimenter held the letter in a vertical position in front of his breast. The subject had to determine which letter was being shown to him and in which direction, whether right side up, bottom side up, or sideways, the letter was being held. This test was considered an accurate basis of indicating the comparative adequacy of the various systems tested in enabling a pedestrian or driver to distinguish the features and character of approaching objects.

These visual efficiency tests really gave the net effect produced by the illumination on a vertical plane and the efficiency under which the eye was operating. The deep bowl reflector, for instance, left the eye in a higher state of efficiency for seeing detail, but at

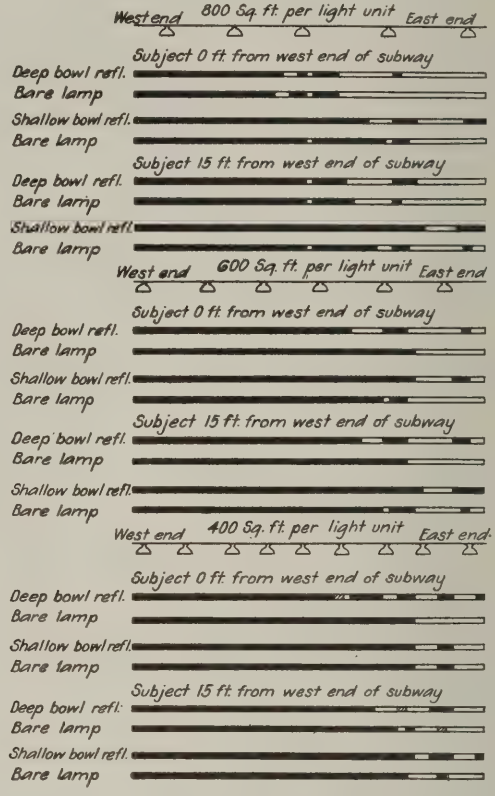

West end 800 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
West end 600 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
West end 400 Sq. ft. per light unit East end
Subject 0 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp
Subject 15 ft. from west end of subway
Deep bowl refl.
Bare lamp
Shallow bowl refl.
Bare lamp

Fig. 12. Graphical Summary Visual Efficiency Tests, With J. P. Puette, Subject.

the same time it threw less light on the vertical plane. The shallow bowl reflector threw more light on the vertical plane at the expense of decreased eye efficiency.

Analysis of Results: General.

1. Reflectors will greatly improve the quality of service given by the installation, justifying many times over the additional expense involved.

2. A careful study of the graphical summaries of visual efficiency tests, hereto attached, indicates that adequate illumination is given by an installation of one 16-candlepower equivalent for every 800 square feet. With one 16-candlepower equivalent for every 600 square feet the results are so highly satisfactory that closer spacing than this should certainly be characterized as uncalled for and wasteful. These conclusions are confirmed by a study of the tabulated summaries of vertical and horizontal illumination tests. They are also amply confirmed by the observations of all those who were present at the tests.

With one 16-candlepower equivalent every 800 square feet, the lighting of both sidewalk and street is markedly better than general street lighting practice of the present day, and fully equal to the best street lighting practice of the present day in business districts, not including the light supplied by lighted windows and signs. With one 16-candlepower equivalent every 600 square feet the illumination results are decidedly superior to the best street lighting practice of the present day in any portion of the country, with the exception of a very limited number of small and exceptional installations.

3. A careful study of the results, particularly of

the graphical summaries of the visual efficiency tests, indicates clearly that the shallow bowl type of reflector is decidedly preferable to the deep bowl type. Both, however, are much preferable to the bare lamp.

Recommendations.

1. If the most highly satisfactory results, with little regard for cost, are desired, it is recommended that one 25-watt-drawn wire Mazda or one 25-watt wire type tungsten lamp, equipped with shallow bowl enameled reflector, of the type illustrated in this report be installed every 600 square feet.

2. If costs of installation and operation are an item, and it is merely sought to obtain a sufficiently satisfactory illumination of the subways for all practical purposes, it is recommended that one 25-watt-drawn wire Mazda or one 25-watt wire type tungsten lamp, equipped with shallow bowl enameled reflector, of the type illustrated in this report, be installed every 800 square feet.

3. It is recommended that the exact location of light units be carefully determined upon for each particular subway by some thoroughly competent illuminating engineer. The general scheme of installation should conform to that indicated in the attached blue prints, showing the test installation in the 54th Place Subway.

4. It is recommended that the feeding system be laid in conduit, the light units being supported by strongly constructed holder sockets attached directly to the conduit. This holder socket should be sufficiently strong, and the construction of the units themselves should be sufficiently strong, so that teamsters cannot tear down or seriously deform the reflectors by striking at them with their whips. The reflectors shown in the attached photographs conform to this requirement.

Approved,

Arthur J. Sweet,
Consulting Engineer on Tests.
May 27, 1913.

In General.

Your Committee, after thorough consideration of the results obtained from the exhaustive tests which were made by the Committee on Tests, are thoroughly convinced that one 16-candlepower lamp or its equivalent for every 800 square feet of covered surface is entirely satisfactory and that any greater amount of illumination should be considered as unnecessary.

We would recommend the following general plan of construction:

Steel cabinets in which to install service switch, cutouts and time switch (where required), wires to be installed in approved galvanized conduit and condulet fittings throughout; weatherproof sockets and enameled steel reflectors of the semi-flat type. That the voltage on lighting circuits should not exceed 110 to 115 volts.

In cases where the lighting circuit is not controlled from a central point nor patrolman provided for turning on and off lights, a time switch should be installed, so as to avoid unnecessary current consumption.

Where current is supplied by some Electric Light Company, that said Electric Light Company be responsible for the operation and maintenance of the lights.

Considering the fact that the cost of lighting a subway depends very largely upon the design of the subway, we would earnestly recommend that hereafter in the designing or constructing of a subway, due consideration be given to the lighting features.

We would recommend the use of a 25-watt Tungsten lamp in place of the 16-c. p. carbon lamp for the reason that with 50% saving in current, 25% more light will be given, and in many cases two of these 25-watt lamps will meet the requirements of three carbon lamps and will save the cost of installing and maintaining one lamp, which would be quite an important item.

We have estimated the cost for installing the system as above outlined, exclusive of the transmission lines, as follows:

Material, including customary percentage	$8.00
Labor, including customary percentage	5.00
Total cost per unit	$13.00

This estimate is approximate only and may be somewhat greater or less according to local conditions.

The item of transmission lines is purposely omitted from this estimate for the reason that if current is purchased, the Company furnishing the current will install the transmission lines without cost to the railroad companies, that is, in all districts where they are now furnishing service. Also the cost of a transmission line will vary greatly according to the distance to which it must be carried. The transmission lines would have to be considered separately in each individual case.

Based upon a rate of 5 cents per kilowatt hour and burning all lamps an average of 12 hours per day, the estimated cost per year per unit is as follows:

Current	$5.47
Lamp renewals	1.59
Maintenance	1.20
Total cost per unit per year	$8.26

Respectfully submitted,

A. J. Farrelly, C. & N. W. Ry., Chairman.
E. A. Bull, C. J. Ry.
C. R. Gilman, C. M. & St. P. Ry.
H. A. Gardiner, C. B. & Q. R. R.
E. W. Jansen, I. C. R. R.
H. C. Meloy, L. S. & M. S. Ry.

At the request of the General Managers' Association the Lake Shore Railroad equipped one of their subways at 63rd & State Sts., Chicago, Ill., according to the recommendations of the committee as given above. This installation was inspected by various railroad and city officials.

NORFOLK & WESTERN ELECTRIFICATION.

Gibbs & Hill, consulting engineers, have recommended the single phase system for the electrification of the 30-mile Elkhorn-Bluefield section of the Norfolk & Western main line. The intention is to use 25 cycle, single phase current at a potential of 11,000 volts at the trolley. Power will be supplied from a power house to be erected at Bluestone, W. Va., with an installed capacity of 27,000 kw. For transmission purposes the potential will be raised to 33,000 volts. In view of the fact that freight trains only are to be handled, the locomotives, of which there will be 24, are to have motors of the induction type, and the control and connections are to be arranged to give three running speeds of approximately 7, 14 and 28 miles an hour. Special attention is being given to the question of regeneration and electric braking on grades, which would decrease the wear and tear on train equipment, and also under favorable conditions tend to reduce the demand on the power house.

Sample Installation According to Committee's Recommendations

Report by Special Commission of Consulting Engineers

Mr. A. J. Farrelly, Chairman,
Subway Lighting Committee,
Chicago, Ill.

Dear Sir:

Pursuant to your request, on Friday night, May 23rd, at the Sixty-third Street subway, to make rough check measurements on the illumination obtained by the lighting installation then installed in said subway,

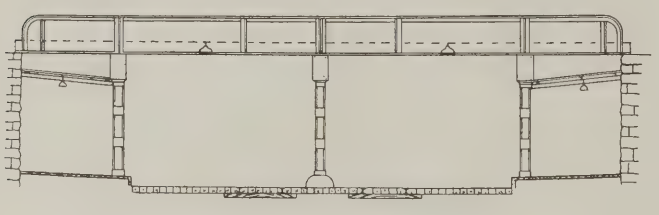


Fig. 14. Section Through Subway.

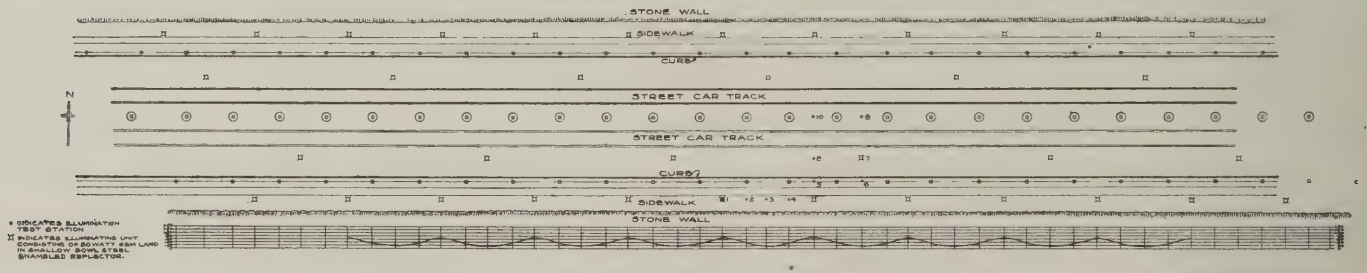


Fig. 13. Layout of Subway with Test Stations and Illumination Curve, Submitted by Special Commission of Engineers.

the undersigned have the honor to submit the attached record of observations, together with sketches showing the general arrangement of the installation, and an illumination curve from the uncorrected measurements, taken on a line directly under the illuminating units. Readings were taken at the representative stations shown on the sketch, the remaining points on the curve being interpolated therefrom.

The instruments used in these measurements have not been checked, and we therefore submit this data as complying with your request for approximate measurement only.

Very truly yours,
(Signed) F. A. Vaughn,
F. A. Rogers,
E. O. Sessions.

COMMUNICATION FROM A. J. SWEET.

Mr. A. J. Farrelly, Chairman, Committee of Railway Representatives on Subway Lighting Conditions,
Chicago, Ill.

Dear Sir:

Referring to the inspection of subway lighting which I made last evening in company with yourself and Mr. H. C. Meloy of the Lake Shore & Michigan Southern R. R., I beg to express myself as follows:

Our inspection covered the 63rd St. subway, between State Street and Wentworth Avenue, of the Lake Shore & Michigan Southern R.R., and the subway under the Chicago & Northwestern and the C., B. & Q. tracks at Robey and 16th Streets. It is my understanding that the 63rd St. subway is laid out on a basis of approximately one 16-c. p. equivalent for every 800 sq. ft. of subway and that this represents what the railway engineers consider to be adequate subway lighting; while the Robey St. subway is laid out on a basis of approximately one 16-c. p. equivalent for every 400 sq. ft. and represents what the engineers of the City of Chicago demand in the way of subway lighting.

The 63rd St. installation represents, in my opinion, splendid street or subway lighting, as measured by the standard set by present general practice in street lighting. The illumination on the sidewalk is fully equal to that of adjacent streets at points where such streets are bordered by store fronts with brightly illuminated windows, and is many times more brightly illuminated than the sidewalks of adjacent streets at points where such sidewalks have to depend wholly on the public street lighting installation for their illumination. Ordinary newspaper print can be very easily read at any point along the sidewalk, and a person's features can be clearly seen at least 80 feet away.

The illumination in the driveway portion of the subway will average at least several times brighter than the illumination on the driveways of adjacent streets. The subway driveway is, moreover, very much more uniformly illuminated than the driveways of adjacent streets. Some large reels of cable had been left in the driveway near one end of the subway, and these, being of almost identical color with the roadway, afforded an unusually severe test of seeing ability. Nevertheless, I found that these reels were sufficiently distinct at 190 feet distance so that no alert driver could have failed to notice them, while at a very much greater distance the reels were visible to anyone consciously endeavoring to distinguish them. On the adjacent streets there were in nearly all cases extensive dark areas between adjacent lamps. The poorest illuminated point on the roadway in the subway portion was, at extremely conservative estimate, at least ten times as bright as these dark areas between lamps on the adjacent streets.

The sidewalks in the 63rd St. subway were better lighted than the streets, a condition in fullest accord with the requirements of the service and with good illumination practice.

The illumination of the 63rd St. subway, in both driveway and sidewalk portions, is so markedly superior to the illumination of adjacent streets that I do not see how any reputable engineer or fairminded laymen could honestly question such superiority.

The Robey St. subway is, as was obviously to be

expected, considerably more brillantly illuminated than the 63rd St. subway. The arrangement of lighting units and the type of reflector in the Robey St. subway are not as satisfactory as the arrangement and type of reflector in the 63rd St. subway, but the fact that double the amount of light is provided per square foot of subway insures a more brilliant lighting. The Robey St. subway stands out in almost ridiculous contrast to the lighting of its adjacent streets, such adjacent streets being, for the most part, so faintly illuminated that ruts or obstruction in the street are not visible until one is close upon them.

As an illuminating engineer who has made a special study of street lighting, I can see no reason whatever why subways of the character here in question should be illuminated to a degree out of all proportion to the adjacent street lighting. Such subways should, perhaps, be illuminated to an equal degree to which the adjacent streets are illuminated by both the public and private lighting of such adjacent streets. It seems to me, however, unreasonable to contend that a subway should be lighted any more than meets this requirement and is, in my opinion, first-class subway lighting as measured by standards at present set by general street lighting practice. As stated above, I consider this to be the correct and fair measure.

When very marked advances shall have been made in general street lighting practice, it may be reasonable to consider lighting subways to such a degree as represented by the Robey St. installation. Under present conditions of practice, such brilliancy of subway lighting is uncalled-for and unreasonable.

Very truly yours,

Arthur J. Sweet.

Vaughn, Meyer & Sweet, Consulting Engineers, Milwaukee, Wis.

Decision of Supreme Court of Illinois

Docket No. 7782* Agenda 56-7, October, 1911—City of Chicago, Defendant in Error, V. Pennsylvania Company, Plantiff in Error

MR. JUSTICE COOKE delivered the opinion of the court:

The city of Chicago brought suit against the Pennsylvania Company in the Municipal Court to recover a penalty for failure to maintain lights in the subway over which the lines of said Company cross Twenty-second street, the city of Chicago. The city based its rights to recover on section 1997 of its Municipal Code of 1905, which is as follows:

"1997. **Lights at Crossings.** Every person or corporation owning or operating any steam, elevated or street railway whose track or tracks cross or intersect at, above or below grade any of the streets within the city, shall, and they are hereby required to, provide at their own expense proper and sufficient lights, and care for the same, at all such crossings or intersections. Such lights shall be of such kind as may be approved by the commissioner of public works."

Section 1998 provides for a fine of not less than $10 nor more than $100 for a failure to comply with the provisions of the proceeding section. The city secured judgment in the municipal court and a fine of $50 was assessed against the railroad company, and this writ of error has been sued out to review the record of the municipal court.

There is no dispute in regard to the facts. For many years prior to 1900 the plaintiff in error or its predecessors had operated a steam railroad on the surface of Stewart Avenue, which runs north and south and across Twenty-second street. This occupation of Stewart Avenue prior to 1900 was authorized by various city ordinances which are not involved in this proceeding. On June 18, 1900, the city council of the defendant in error passed an ordinance requiring the plaintiff in error to elevate its tracks from twenty-first street southwardly to fifty-third street. This ordinance provided for subways to be constructed by plaintiff in error in certain streets, among which was Twenty-second street. The character of the subway provided for in Twenty-second street was specified in the ordinance, and it has been constructed in accordance therewith and accepted by defendant in error. The distance from the surface of the roadway to the railroad structure above is 13.5 feet. That evidence shows that as a result of the overhead crossing the street beneath same is somewhat darkened in the daytime and is rendered darker at night than it otherwise would be; that lights are required in the said subway to protect the public from the danger of collisions, and also from the danger of coming in contact with iron posts erected in the roadway to support the superstructure of the railroad; that after the completion of the elevation of its tracks in 1908, plaintiff in error maintained lights in said subway until January 15, 1909, when it ceased to light said subway and has since refused to do so. Plaintiff in error offered to prove that defendant in error appropriated a large sum of money annually for street lighting and that plaintiff in error has paid the taxes assessed against it for such purposes. This evidence was excluded by the trial court.

Plaintiff in error contends that the track elevation ordinance of 1900, when accepted and complied with by it, became a contract, which cannot be changed without the consent of both parties, and that defendant in error cannot cast additional burden upon it unless it be in the reasonable exercise of the police power; that even if the power to impose the burden of lighting the street intersections exists when it crosses a street at grade, it ceases when the railroad is elevated and the dangers of the grade crossing are eliminated; that defendant in error has no power, in the absence of a statuory provision, to pass an ordinance requiring railroad companies to light their tracks within the city; that the defendant in error having assumed the duty of lighting its streets, cannot relieve itself of such burden by an ordinance placing the burden upon the railroad company; that to place the burden of lighting this subway upon the railroad company is taking of its property for public use without just compensation and is a denial to the company of the equal protection of the laws, in violation of both the State and Federal constitutions.

If the city has the right to impose this duty upon plaintiff in error it is only because of the general police power possessed by it. No express grant has been given by the state which authorizes it to require a railroad company to maintain lights at any particular place. There is, however, a general police power possessed by the city by which all persons natural or artificial may be subjected to such reasonable restrictions and requirements as are found to be proper and requisitite to secure the health comfort and convenience of the people. (*City of Chicago v. Union Traction Company* 199 *Ill.* 259) The general police power thus possessed by a city is a continuing power and is one of which a city cannot divert itself, by contract or otherwise. It follows therefore, that if the defendant in error has the right to impose this duty upon plaintiff in error as a valid exercise of its police power, the contention that the track elevation ordinance constitutes a contract which is violated by section 1997 of the municipal code cannot be sustained. Whether, in any event, a city has the power without an express grant from the legislature, to require rialroads to maintain lights at grade crossings is urged at considerable length. In the view we take it is not necessary to determine that question. The railroad does not cross twenty-second street at grade. The conditions there are essentially different from those of a grade crossing, and the rights of the city in reference to the regulation of the operation of a railroad on an elevated structure are not the same as at grade crossings. This was recognized by the city when it provided in the elevation ordinance that when the railroad should be operated on the elevated structure the provisions of all the ordinances of the city of Chicago relating to the speed of trains, the length of trains, the number of cars to constitute a train, and the maintenance of gates, flagman, watchman, signals, and signal towers, and the ringing of bells should

cease. Even if the power exists in the city to require railroads to furnish lights at grade crossings, it would not necessarily follow that it existed when the grades had been separated and the railroad was being operated on an elevated structure. The statue requiring a bell to be rung for eighty rods before reaching a crossing has no application to a crossing under a viaduct, where the travel is over the elevated structure and it out of the way of the trains passing over the tracts. *Cleveland, Cincinnati, Chicago and St. Louis Railway Co. v. Halbert* 179 Ill 196 *Blanchard v. Lake Shore and Michigan Southern Railway Company* 126 Id 416.

In people v Illinois Central Railroad Company 235 Ill. 374, the City of Chicago sought by mandamus to compel the railroad company to reconstruct the pavement and repair the sidewalk in a subway in one of the streets in the city which passed under the elevated structure of the railroad company. In that case the railroad company has been required to elevate its tracks by an ordinance of the city, and at the subway in question was required by the elevation ordinance to pay for the cost of constructing suitable approaches to the depressed street and of paving the street under the railroad tracks and the approaches thereto, and to construct suitable sidewalks. The City had repeatedly notified the railroad company that the pavement and sidewalks in the subways had become so worn as to be unsafe and to require immediate reconstruction, and demanded that it reconstruct the pavement and repair the sidewalks. This the railroad company refused to do and a petition for the writ of mandamus was filed by the city. The city in that case contended that it had the right in the exercise of its police power under section 8 of the act in relation to fencing and operating railroads, to require this to be done by the railroad company. In passing upon that question we said: "Here the street in question did not cross the railroad tracks but passed under them. Appellee (Railroad Company) is required to maintain its structure supporting the tracks in such condition as to render it safe for persons and property passing underneath them, but nothing it could do in the way of maintaining and re-paving the streets would afford any protection from trains to persons and property passing underneath their tracks. It is not denied that when the appellee elevated its tracks it restored the streets and sidewalks to proper condition, and in our opinion its duty ended there. The future maintenance of the streets was not imposed upon the corporation by its charter nor by any law passed in the exercise of the police powers of the state." While the precise question to be determined here was not involved in that case, the facts are analogous and the reasoning in that case applies here.

The police power is limited to the enactment of laws demanded for the public health, comfort, safety and welfare of society. (*Ruhstart v. People,* 185-Ill. 133) By elevating its roadbed and separating its grade from the grade of the street all danger of collisions between trains of the plaintiff in error and persons or property was entirely eliminated. In passing along the street in the subway beneath the tracks of plaintiff in error no danger is encountered by reason of the operation of the train of Plaintiff in error. Under the exercise of the police power the only excuse which could be given to support the right to the city to require plaintiff in error to maintain lights in this subway would be that the same were necessary for the protection of the public on account of the operation of the railroad through the running of its trains. That the public is no longer in danger because of the operation of the trains of plaintiff in error is conceded. It is only contended that defendant in error has the right to require plaintiff in error to maintain lights at this subway because the building of the structure required by the elevation ordinance has darkened the street. Plaintiff in error has a right to maintain its tracks across twenty-second street by reason of the license given it by the defendant in error to do so. Under the elevation ordinance it had the right to erect the structure it has erected across twenty-second street. The city has no more right to require the plaintiff in error to maintain lights in this subway merely for the reason that its structure has tended to darken the street, than it has to require the owners of buildings along the line of any street to keep the street lighted because the buildings on account of their height have tended to darken the street and make it less safe for travel. To require plaintiff in error to maintain such lights would be to deny it to the equal protection of the laws.

Defendant in error, in support of its contention relies chiefly upon the case of *City of Chicago v. Union Traction Co.* supra. But that case is of no controlling force here. In that case it was clearly shown that the street accumulations had a deleterious effect upon the public health and comfort, and that on account of the manner in which the roadbed was constructed and the rails were laid in the street, the dirt and filth had a tendency to collect between the rails and be retained there. As the existence of the rails in the street and the peculiar construction of the roadbed tended to refrain the street accumulations and prevent them from flushing off to the sides of the street, it was properly held that the city had the power under the exercise of its police power, to require the traction company to remove such accumulations. The decision of the case rested upon the fact that the rails caused an accumulation and retention of agencies of disease which were injurious to the public health.

Section 1997 of the municipal code in so far as it applies to railroad crossings on elevated structures above the grades of streets, is invalid.

The judgment of the municipal court is reversed.

Judgment reversed.

HIGHER ELECTRIC LAMP EFFICIENCY.

The General Electric Company is about to announce further advances in the direction of higher efficiency of the incandescent lamp. The new lamps contain especially shaped tungsten filaments and are filled with inert gas, such as nitrogen, at a pressure of about an atmosphere. The types which it is expected to first develop are adapted to comparatively high current consumption, 5 amperes and above, and operate at an efficiency of half a watt per candlepower. This is fully twice as high an efficiency as the most efficient incandescent lamps heretofore available. The new lamps promise to be of particular value in a field not heretofore covered by incandescent lamps, and should greatly broaden the application in which they can be used advantageously, particularly in the direction of very large candlepower units.

The research leading to this discovery has been going on in the Research Laboratory of the General Electric Company at Schenectady for several years.

RAILWAY BUSINESS FOR MAY.

During May the railways of the United States received for their services to the public an average of $8,230,000 a day; it cost to run their trains and for other expenses of operation $5,920,000 a day; their taxes were $341,500 a day; their operating income $1,-972,322 a day for the 220,897 miles of line reporting, or at the rate of $8.93 for each mile of line for each day. Thus for every six dollars of their earnings which remained available for rentals, interest on bonds, appropriation for betterments, improvements and new construction, and for dividends, the railways had to pay more than one dollar in taxes.

All of these amounts are substantially greater than the similar returns for May, 1912. They are from the summary of the earnings and expenses compiled by the Bureau of Railway Economics from the monthly reports of the steam railways of the United States to the Interstate Commerce Commission. They include over 95 per cent of the mileage and earnings of all of the railways of the country.

ELECTRIC WIRING AND LIGHTING.

The American School of Correspondence has recently issued a new book on "Electric Wiring and Lighting," by Knox and Shaad, which will be of interest and value to the "men on the job."

The book shows detailed designs for all kinds of interior wiring, both in conduit molding and on insulators; two and three-wire systems, designs of wiring installations, overhead and underground line work, etc. It also takes up the subject of electric lighting in a very fundamental way.

It is written in good, plain English, with most of the technical features eliminated, which will be appreciated by the practical man. It covers the subject of incandescent lamps, arc lamps, special lamps, illumination shades and reflectors, photometry and allied subjects.

The book retails for $1.00 and can be obtained from the American School of Correspondence, Chicago.

Some Calculations Involved in Electric Traction

The paper entitled "2400 Volt Railway Electrification" presented by Mr. H. M. Hobart before the American Institute of Electrical Engineers last month, contains some very interesting calculations of a fundamental nature which must be employed in comparing the relative merits of steam and electric locomotives. Although no attempt is made to work out detailed quantitative estimates, the paper clearly points out the general order of magnitude and the corresponding causes for steam and electric operation. In this particular instance the service chosen is that in which the steam locomotive would seem to be most strongly entrenched, mainly on express passenger service.

Steam Locomotive.

An express locomotive hauling a passenger train on any one of our Eastern railways will in actual service burn at least 3.5 pounds of good coal per indicated horse-power hour. As a representative train we may take for example a Pacific-type locomotive weighing, complete, 185 tons[1] and hauling 10 modern Pullman coaches constructed of steel and weighing 75 tons each. There is thus an aggregate weight of $10 \times 75 = 750$ tons behind the locomotive. Of the total locomotive weight of 185 tons, the tender accounts for no less than 70 tons. Even of the remaining 115 tons only 85 tons is carried on the three driving axles, or 57,000 pounds per axle. On the basis of a coefficient of adhesion of 0.20, the locomotive can exert a tractive effort of

$$0.20 \times 85 \times 2000 = 34000 \text{ lb.}$$

before slipping the wheels. For the usual requirements of an express passenger service, this limit will rarely be approached. The total train weight amounts to

$$185 + 750 = 935 \text{ tons.}$$

Typical of the service of such trains is the making of non-stop runs of, say, 100 miles in two hours. This corresponds to an average speed of 50 miles per hour. In the course of this 100-mile run, *maximum* speeds of over 60 miles per hour will be attained. The average tractive effort, taken into account the variations in speed, and assuming representative track conditions as regards curves, grades and weight and condition of rail, for a train of this composition, will be roughly 9 lb. per ton.

The total tractive resistance will be

$$9 \times 185 + 9 \times 750 = 1670^* + 6750 = 8420 \text{ lb.}$$

On the basis of an efficiency of 85 per cent from the cylinders to the crank-pins, the power required, averaged over the journey, will be

$$\frac{50 \times 5280 \times 8420}{60 \times 33000 \times 0.85} = 1320 \text{ i.h.p.}$$

On the basis of an average consumption of 3.5 lb. of coal per i.h.p-hr., there will be burned during the journey

$$2 \times 1320 \times 3.5 = 9240 \text{ lb. of coal}$$

or 4620 lb. per hour.

This quantity is based on the use of coal of a calorific value of some 14,000 B.t.u. per pound. Since 1 h.p-hr. = 2545 B.t.u., we may express the calorific value of the coal as:

$$\frac{14{,}000}{2545} = 5.50 \text{ h.p-hr. per lb.}$$

The energy in the coal burned on the journey amounts to

$$9240 \times 5.50 = 50{,}800 \text{ h.p-hr.}$$

The energy output from the cylinders is

$$2 \times 1320 = 2640 \text{ i.h.p-hr.}$$

Consequently the "journey" efficiency from the coal to the cylinders is

$$\frac{2640 \times 100}{50{,}800} = 5.20 \text{ per cent.}$$

It is highly improbable that this "journey" efficiency is ever exceeded in routine steam locomotive haulage.

In accordance with our assumption of 85 per cent for the efficiency from the cylinders to the crank-pins, we obtain for the "journey" efficiency, from the coal to the crank pins,

$$5.20 \times 0.85 = 4.41 \text{ per cent.}$$

But a considerable portion of the energy delivered at the crank-pins is consumed in propelling the locomotive itself. Of the total tractive effort of 8420 lb., no less than 1670 lb. is required for the locomotive, and only 6750 lb. remains available for propelling the train behind the drawbar. Consequently the "journey" efficiency from the coal to the drawbar is only

$$\frac{6750}{8420} \times 4.41 = 3.53 \text{ per cent.}$$

It must furthermore be pointed out that coal is burned wastefully in firing up before the journey and also for a considerable time after the journey.

For the case in hand a fair value to assign to the aggregate of these two components is 3000 lb.

There must consequently be debited to the 100-mile journey a gross coal consumption of

$$9240 + 3000 = 12{,}240 \text{ lb.}$$

This reduces the net efficiency from the coal to the drawbar to

$$\frac{9240}{12{,}240} \times 3.53 = 2.65 \text{ per cent.}$$

Thus per drawbar h.p-hr. we require to burn

$$\frac{5.20}{2.65} \times 3.5 = 6.86 \text{ lb. of coal.}$$

Electric Locomotive.

Now let us consider the hypothetical case of an *electric* locomotive hauling these 10 Pullman coaches over the same distance in the same time.

In order to provide equal margins as regards starting, accelerating, ascending grades, and operation at high speeds, we must, so far as relates to the provision of the same drawbar pull, arrange for the same weight on drivers per ton total weight of train. The steam locomotive had a weight of 85 tons on drivers and the complete train weighed 935 tons. If the electric locomotive were built with the entire weight on drivers, then if by W we designate its weight, and remembering that the weight of the 10 Pullman coaches is 750 tons, we should have the relation

$$W : 85 = (W + 750) : 935$$

Whence $W = 75$ tons

While we thus see that a 75-ton electric locomotive provides the required capacity, it is necessary, in the interests of ensuring smooth running at high speeds, to provide guiding trucks at each end.[2]

Fifteen tons is an approximate figure for the weight of each of these guiding trucks. The correct method of arriving at W, the weight of the locomotive, when, as in the present instance, the speed is such as to require two 15 ton guiding trucks, is as follows.

$$(W - 30) : 85 = (W + 750) : 935$$

Whence $W = 108$ tons

1. The 2000-lb. ton (= 0.9 metric ton) is employed throughout this paper.

*Throughout this paper the accuracy is limited to three significant figures.

The weight on drivers is

$$108 - 30 = 78 \text{ tons}$$

As now modified, we may take the complete weight of the electric locomotive as 108 tons, of which 78 tons is on drivers. For the electric equivalent of our typical steam train we thus have a train with a total weight of

Let each electric locomotive traverse 24,000 traffic miles per annum as against 16,000 traffic miles per annum for each of the steam locomotives.[4] In both cases the total traffic amounts to 240,000 locomotive miles per annum.

When hauling a 1400-ton train up a 1.5-per cent grade at 6.5 miles per hour, the output at the drawbar is

$$\frac{6.5 \times 5280 \times 38 \times 1400}{60 \times 33{,}000} = 923 \text{ h.p.}$$

The corresponding output from the cylinders of the 250-ton steam locomotive is

$$\frac{1670 \times 923}{1400 \times 0.75} = 1450 \text{ i.h.p.}$$

On the basis of employing as fuel Western lignite of a calorific value of 11,000 B.t.u. per pound (4.32 h.p-hr. per pound), the coal consumption may be taken at 5 lb. per i.h.p-hr. while the locomotive is hauling its train under these conditions of maximum load. Thus we have a coal consumption of

$$\frac{1450 \times 5}{6.5} = 1120 \text{ lb. per train mile}$$

Let it be premised that the average load for the entire 16,000 traffic miles traversed by the locomotive in a year, is only one-third of this maximum load. The average coal consumption with which the locomotive must be debited per train-mile, will not, however, fall to $1120/3 = 373$ lb. per train-mile, for we must make allowance for the large amount of coal burned in the course of the many hours during which the locomotive is standing still, but with fires up.[5] We shall be decidedly favoring the steam locomotive in this comparison if we debit it with an average coal consumption of 560 lb. per locomotive-mile for the 16,000 miles which it travels annually. On the basis of $2.50 per ton, the fuel cost amounts to

$$\frac{560}{2000} \times 2.50 = \$0.685 \text{ per train-mile}$$

In the case of the electric locomotive we shall supply the drawbar pull at a 50 per cent higher speed. Consequently on the 1.5-per cent grades, the power at the drawbar will be

$$923 \times 1.5 = 1390 \text{ h.p.}$$

The output at the drivers of the electric locomotive will be

$$\frac{1560}{1400} \times 1390 = 1550 \text{ h.p.}$$

The input to the sub-stations per train-mile will be

$$\frac{1550 \times 0.746}{0.87} = 1330 \text{ kw.}$$

The input to the sub-stations per train-mile will be

$$\frac{1330}{0.93 \times 0.78 \times 6.5 \times 1.5} = 188 \text{ kw-hr.}$$

But this input corresponds to the load on the ruling grade. We have already premised an average load equal to one-third of the maximum load. Consequently we have

$$\text{Average imput to sub-stations} = \frac{188}{3} = 63 \text{ kw-hr. per}$$

locomotive-mile.

On the basis of a price of one cent per kw-hr. delivered to the sub-stations, the average cost of the electricity per locomotive-mile comes to

$$63 \times 0.1 = \$0.63$$

This is in comparison with the average cost of $0.685 for fuel per locomotive-mile corresponding to a price of $2.50 per ton of lignite.

The item of wages for the locomotive crew, will be taken at 20 cents per mile both for the steam locomotive, and for the electric locomotive.

Appropriate *relative* figures for repairs and maintenance are $(10 \times 2.5 =)$ 25 cents per mile for the steam locomotive, and $(4 \times 1.6 =)$ 6.4 cents per mile for the electric locomotive.

As to capital outlay for locomotives, $45,000 for each steam locomotive can fairly be compared with $72,000 for the electric locomotive. This is a fair *ratio* and suggests a reasonable order of magnitude. In spite of the simplicity and strength of the electric locomotive, let us credit it with only the same life, in years, as the complicated and vulnerable steam-locomotive and let us take the life as 15 years. Let taxes, and insurance amount to 3 per cent. Consequently as annual charges on the capital outlay for locomotives, we may fairly take $(5 + 4.6 + 3) = 12.6$ per cent in each case. This comes to $5,670 per annum for each steam locomotive and $9,060 per annum for each electric locomotive. These figures reduce to

$$\frac{567{,}000}{16{,}000} = 35.4 \text{ cents}$$

per mile for the steam locomotive and

$$\frac{906{,}000}{24{,}000} = 37.8 \text{ cents}$$

per mile for the electric locomotive.

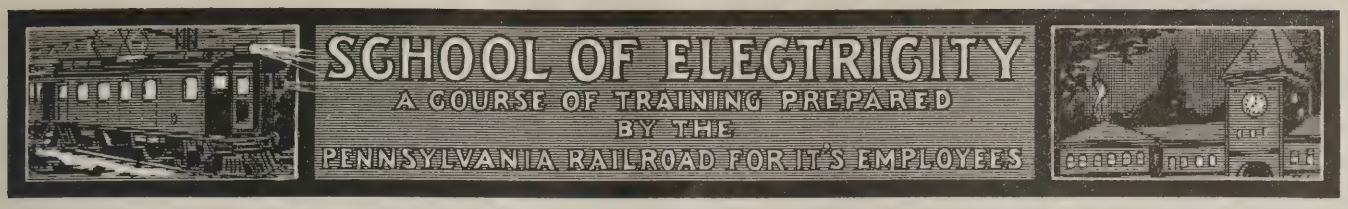
Thus for the five component costs which we have considered, the results are as follows:

	Per Locomotive-mile. Steam	Electric
I.—Fuel	$0.685	———
II.—Electricity	———	$0.630
III.—Wages of locomotive crews	0.200	0.200
IV.—Repairs and maintenance of locomotives	0.250	0.064
V.—Interest, taxes, insurance and amortization	0.354	0.378
Totals of above 5 items	$1.489	$1.272

(To be continued in September issue.)

4. Experience has demonstrated that an electric locomotive will be available for service every day for eleven out of the twelve months of the year, the remaining month affording a liberal margin for general repairs. During the $(11/12 \times 365 =)$ 33 days of service, even a low-speed electric locomotive hauling freight over a mountain division, will readily yield 100 miles per day. This works out at an annual mileage of 33,400. It is exceedingly conservative to cut this down to 24,000 miles, or an average of $(24{,}000/334 =)$ 72 miles per day, averaged over 334 days, or $(24{,}000/365 =)$ 66 miles per day, averaged over 365 days.
On the other hand, to credit each steam locomotive with $(16{,}000/365 =)$ 44 miles per day, when averaged over the 365 days in the year, is to take an exceedingly high figure which is seldom if ever reached by Mallets when dealing with the class of service on which the example is based.

5. At page 53 of Ripley's "Railroad's Rates and Regulations" (Longman's, Green and Co., 1912), the author in discussing the cost of fuel for motive power, writes: "'This item, amounting in 1905 to no less than $156,000,000 for the railroads of the United States, was the largest in the budget, constituting 11 per cent of all operating expenses. Yet brief consideration shows that even here much of this expense is constant and invariable. A locomotive will burn fully one-third as much coal merely to move its own weight as to haul a loaded train. Five to ten per cent of its total daily consumption is required merely for firing up to the steaming point. Twenty-five to 50 pounds of coal per hour go to waste in holding steam pressure while a freight train is waiting on a siding. Every stop of a train going thirty miles per hour dissipates energy enough to have carried it two miles along a level road. In brief, expert evidence shows that of this important expenditure for coal 30 to 50 per cent is entirely independent of the number of cars or the amount of freight handled."



EDITOR'S NOTE:

Through the courtesy of the officials of the Pennsylvania Railroad, we have been given special permission to publish this entire course in the *Railway Electrical Engineer*, so this valuable training in electricity, which was originally intended only for P. R. R. men, now becomes available to all railroad men. A complete lesson of this course will be published in each issue.

Lesson No. 3

PRIMARY CELLS.

The principal sources of current electricity with which we shall have occasion to deal are the primary battery and the dynamo. In the present paper are the descriptions of three general types of primary cells used extensively for various purposes and with which it is advisable to become familiar.

The action between different metals as used at present in our primary batteries was first detected by Galvani, an Italian, in 1786, when he was making some experiments with frogs' legs which he had supported by the spinal cord upon copper hooks fastened to a strip of iron. He noticed that the legs contracted to a considerable degree when the muscles happened to touch the iron, which indicated to him that some action must be taking place. This chance experiment led to the production of our present electrolytic cells. The name "galvanic battery" was thus originated.

A simple cell may be made by merely inserting a strip of zinc and one of copper in a jar partly filled with water and a small amount of acid, or even with salt and water for a solution. This solution in which the elements are immersed is called the Electrolyte. By joining the copper and zinc strips by means of a metallic conductor outside the jar, keeping the strips separated in the electrolyte, a current of electricity will be produced, and it is said to flow from the copper strip through the electrolyte back to the zinc. It then passes from the zinc through the electrolyte to the copper. The exact manner in which the current passes through the electrolyte is not well understood, but it is accompanied by the oxidation of the zinc which is in reality a slow burning process. At the same time hydrogen gas is formed at the copper plate, known as the negative element in this combination.

The element from which the current leaves the cell is connected to the positive binding post or terminal (+), but is the negative element or cathode, while the element through which the current enters the cell is connected to the negative binding post or terminal (—), but is the positive element or anode. In the above cell the copper forms the positive terminal and the zinc the negative terminal.

The primary cause of the flow of current in an electrolytic cell is chemical action between the electrolyte and elements known as the oxidation or combustion of the positive element. If the cell is properly designed, the amount of current which can be supplied is proportional to the amount of material consumed in the positive element.

The cell is said to Polarize when the hydrogen gas, which is formed by the chemical action, collects in bubbles upon the negative element. This gas on the negative element greatly increases the internal resistance of the cell which correspondingly reduces the current flowing and the efficiency of the cell. Means can be provided to prevent this gas formation on the negative element. This is accomplished by supplying certain chemicals known as Depolarizers which unite with the hydrogen before it collects on the negative element. The kind of Depolarizer is determined by the type of cell.

The positive and negative elements of a cell are determined by the relative intensity of the chemical action of the electrolyte upon the plates forming the elements. The more intense action takes place at the positive plate. The following table is arranged with the most positive first, although authorities differ somewhat upon the order in which the elements should appear. Their order is different in the different electrolytes.

1. Aluminum.	11. Iron.
2. Zinc.	12. Steel.
3. Tin.	13. Copper.
4. Cadmium.	14. Silver.
5. Lead.	15. Gold.
6. Antimony.	16. Carbon.
7. Bismuth.	17. Platinum.
8. German Silver.	18. Iron Sulphite.
9. Brass.	19. Manganese Dioxide.
10. Mercury.	20. Lead Peroxide.

From the above table it is then seen that any element mentioned may be taken as positive and any of those following it in the list would then be negative to that particular element, the greater voltage being secured from those farthest apart in the list. In the practical battery, however, the cost of the elements and the convenience of handling determine which are best adapted.

Different solutions are used for electrolytes, each one being especially adapted for some particular type of cell. The following is a list of compounds so used: caustic potash, caustic soda, ammonia, sulphuric acid, nitric acid, hydrochloric acid, stannous chloride, stannic chloride, iron chloride, silver nitrate, copper sulphate (blue stone), zinc sulphate, ferrous sulphate, potassium iodide, ammonium chloride (sal ammoniac), sodium chloride (common salt).

Current Direction.

In a circuit the current is said to always flow from a positive toward a negative source, thus in the external circuit of a cell that pole or terminal which would be considered as positive would be negative when considered with reference to the direction of the current flow of the internal circuit or inside the cell.

The principal reason for primary batteries not being used at the present time for large power producers is that the same power may be produced much more cheaply by means of the dynamo electric machine, which also occupies much less space and requires less attention than the primary battery.

Voltaic Action and Local Action.

There are two kinds of chemical action which take place in the electrolytic cells: (a) Voltaic Action, which occurs only when current is flowing; (b) Local Action, which exists whether or not current is flowing. The Voltaic Action is essential to the operation of the cell and its energy is available for maintaining the current.

Local action takes place to a greater or less extent in all primary cells and its presence represents an absolute waste. This local action is usually caused by the presence of impurities in the elements, which are responsible for chemical action between the elements and these impurities in the presence of the electrolyte. This action continues, setting up local currents, eating away the element until the foreign substance is set free and falls to the bottom of the jar.

A means sometimes employed to remedy this trouble is to amalgamate the surface of the zinc plate with a film of liquid mercury. To do this the plate must be carefully cleaned, any grease present should be removed by the use of potash or soda and then immersed for a few moments in an acid. The acid to be used for the electrolyte will be satisfactory. This makes a very clean surface on the zinc cell.

immersed in it. This prevents the electrolyte from attacking the zinc when current is not being drawn from the over which the mercury spreads quickly and evenly when

Primary cells may be divided into two general classes depending upon the service for which they are used, namely: open and closed circuit cells. The Open Circuit cells are those, which, on account of their construction and nature of the plates, are not suitable to furnish current continuously. They are designed to furnish current for short time intervals only, but these may be some time apart, like the operation of a door bell, telephone, etc. These cells must necessarily be quite free from local action, else they would literally exhaust themselves. The common dry cell is a good example. The Closed Circuit cells are designed to give continuously a constant current of uniform voltage for a considerable length of time. They must be free from polarization. Gravity, Edison and Gordon cells are all closed circuit cells. Most Telegraph circuits operate on closed circuits and necessarily employ closed circuit batteries.

Rating of Cells.

The capacity of many cells are rated in Ampere Hours,

as the Gordon 300 ampere hour cell. This term has reference to the total current output which can be obtained from the action of the cell, and is based upon the current supplied and the period of time for which it can supply this current. In other words, it is the product of the current and time.

Take, for an example, a single cell on a circuit supplying 0.5 amperes continuously for 26 days. The total time this cell was operating was 624 hours. Then the product of time and current would be $624 \times 0.5 = 312$, the number of ampere hours supplied by the cell in the given time. If this had been an intermittent current, that is, not a constant current, but one used at certain intervals of say 10 minutes per hour for this same length of time, then the total time the cell would be furnishing the current would be 24×10 or 240 minutes or 4 hours per day. The total time this current 0.5 ampere was furnished would be 26×4 or 104 hours and the total current output would be 104×0.5 or 52 ampere hours. Assuming that the cell used was of 400 ampere hour capacity, then it would last approximately $400 \div (4 \times .5)$ or 200 days, a little over six months, on the circuit discharging ½ ampere for 10 minutes each hour.

The Internal Resistance of a cell is the resistance to the flow of current through the cell offered by the electrolyte. This varies in the same cell for different current outputs. Low internal resistance is desirable when large current output is required, but it is not so important if the circuit outside the cell is of comparatively high resistance. If E is the voltage of the cell on open circuit, V the voltage of the cell when the external resistance of the cell is closed, and I the current, then the internal resistance of the cell is

$$R = \frac{E - V}{I}. \qquad \text{Eq. (1).}$$

Example: A primary cell on open circuit has a voltage of 0.95 volts. When it is furnishing current at the rate of .8 amperes, the voltage falls to 0.7 volts. What is the internal resistance of the cell or battery?

Solution: From equation 1, this resistance is found by dividing the difference between the open and closed circuit voltage by the current in amperes.

In the problem $E = .95$, $V = .7$ and $I = .8$. Then substituting these values in the equation, it would be written as follows:

$$R = \frac{.95 - .7}{.8} = \frac{.25}{.8} = .31 + = \text{the number of ohms}$$

internal resistance.

The lower the internal resistance of the cell, the greater is the total amount of energy available for the external circuit and the electrical efficiency is correspondingly increased.

The positive and negative terminals or binding posts are so named from the fact that the current in the circuit outside of the cell always flows from one terminal through the circuit and back to the cell through the second terminal. That one *from which* the current flows is always designated as *positive,* and is marked (+), while the one by which the current returns to the cell is known as the *negative,* and is marked (—).

In referring to positive or negative *elements* or *electrodes* of a cell, it is meant those parts of a cell from which and to which the current passes inside the cell. For instance: the current inside a gravity cell, shown in Fig. 1, flows *from* the zinc *to* the copper plates. This means that the zinc is the *positive element* or electrode and copper the *negative element* or electrode. The external circuit just reverses this condition, as the current comes out of the cell through the copper electrode or terminal, which is known as positive terminal, and returns through the zinc or negative terminal. These conditions may be confusing and should be thoroughly and clearly understood, as it is always important that the cells be connected correctly. This may be understood better by referring to the diagram showing the course or direction of current through a gravity cell in Fig. 1-A.

Authorities differ in the use of the term electrode so that care should be taken when using it. A safe course to follow is to mention an electrode with reference to the kind of the plate, thus, in a gravity cell—the copper electrode or the zinc electrode, etc., instead of designating them as positive or negative electrodes.

GRAVITY CELL.

Where Used.

The Gravity Cell, shown in Fig. 1, is used principally on closed circuits where there is a constant drain on the battery; for the operation of relays and sounders in telegraph work; for transmitter batteries on switchboards and telephones to a limited extent; in some cases for railroad signal work at interlocking points; operation of automatic signals and for track circuits.

Installing or Setting Up.

The containing jar of glass which holds about a gallon, being 6 inches in diameter by 8 inches high, should be thoroughly cleaned.

The *elements* consist of copper and zinc plates.

The *electrolyte* or solution consists of copper sulphate in water forming the clear blue solution in the bottom and the colorless zinc sulphate solution which is formed by chemical action at the top of the cell.

The copper (positive terminal, but negative element) for the bottom of the cell should be provided with a rubber insulated wire long enough to reach above the top of the liquid. This wire is rubber-covered to prevent action of the chemicals on the copper conductor and to keep the wire from coming in contact with the zinc plate and causing a short circuit. Before placing the copper electrode in the bottom of the jar, the copper plate should be opened up in star shape so that it will stand on edge.

The connection to the zinc (negative terminal, but positive element) is usually made by means of a binding post which is part of this element, and which engages with that part used to suspend the zinc on the side of the jar.

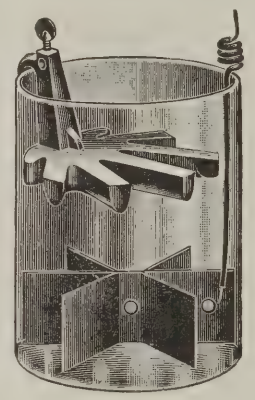


Fig. 1.

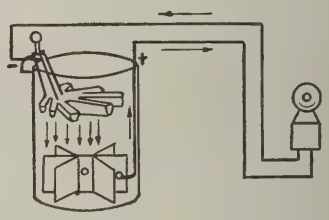


Fig. 1-A.

The star-shaped copper with wire attached is first placed in the bottom of the jar, the wire extending above the top of the jar. About three pounds of *blue vitriol* or *blue stone* crystals which are free from dirt and other impurities and of a size not smaller than a pea nor larger than a hen's egg, are then evenly distributed in the spaces between the different arms of the copper plate.

The zinc plate should then be suspended securely to the top of the jar so that it will be about four inches above the copper plate. Pure water containing no iron or other impurities (rain water is usually satisfactory) should be used. This is poured in and should be sufficient to cover the zinc.

Better and quicker action of the cell will be secured and it will be ready for service sooner if some of the colorless solution of zinc sulphate is saved from the old cells and added to the new solution. Quick action is also secured by adding a small amount of sulphuric acid or common salt or short circuiting the cell for one or two days.

If there is none of the zinc sulphate solution nor sulphuric acid added when the cell is first set up, it should be short circuited (that is, it should be connected between the copper and zinc terminals with a piece of wire) for one or two days to form sulphate of zinc and at the same time lower the internal resistance. This will also protect the zinc from chemical action as the zinc sulphate surrounds the zinc element. They should be kept in a room whose temperature is 70 to 85 or 90 degrees Fahrenheit, as the internal resistance, which is normally 2 or 3 ohms, increases very rapidly with a drop in temperature below this point, 70 degrees. For this reason they should be kept in a warm place as heat promotes chemical action upon which the cell depends for its operation. The blue line marking the boundary between the blue copper sulphate solution in the bottom of the cell and the colorless zinc sulphate solution in the top of the cell should be about half way between the copper and zinc elements.

These solutions remain separate on account of their different specific gravities or densities, the colorless zinc sulphate being lighter in weight for the same volume. It is from this fact that the cell derives its name, "Gravity Cell," sometimes called *Blue Stone Cell.* If the blue line marking the boundary between the two solutions is above this point, some of the blue solution or copper sulphate can be siphoned off or the cell may be short circuited to form more of the zinc sulphate or colorless solution. When the blue line is too low, more of the blue stone or copper sulphate crystals and water should be added.

A clear blue color at the bottom of the cell, the dividing line between the solutions about midway between the elements and

a colorless solution in the top of the cell, indicates that it is in good condition, but brown color in any part indicates that the cell is deteriorating. This cell does not polarize, meaning that hydrogen gas does not form on the negative element, which is a common fault with many types of electrolytic cells, if blue stone crystals are kept in the bottom of the cell, as they prevent the cell from polarizing.

If this cell is used on open circuit and it does not have sufficient work to do, the two solutions are very likely to mix, and when the copper sulphate comes in contact with the zinc electrode, the copper sulphate is decomposed. The oxygen of the sulphate unites with the zinc, forming zinc oxide, and the copper deposits itself on the zinc like black or dark brown mud.

This deposit sometimes takes the form of streamers hanging from the zinc and may reach to the bottom of the cell. When in this condition the cell has practically no value for producing current and should be completely cleaned. If the elements (zinc and copper) are badly decomposed or eaten, they should be replaced by new ones. Save the old elements as they can be sold for junk.

A deposit forms on the zinc which can be cleaned off, while pure copper is deposited on the copper element, especially when the cell is in action. If the copper plate is to be used when renewing the cell the crystals of copper should be knocked off.

Sulphate of zinc is constantly forming in the top of the cell as long as the cell is in action. When this becomes too dense (above 1.15 specific gravity) it is necessary to draw out a portion of the top liquid and replace with clear water.

The best operation is secured if the cell is operated on closed circuit about 60 per cent of the time. When the cell is on open circuit too long, the solutions mix and the cell is not ready for immediate use.

When in good condition, the cell generates an electromotive force (E. M. F.) of 1 volt and on continuous work will operate very satisfactorily with an output of about ¼ ampere.

Cleaning Cells.

When used constantly they should be cleaned about every three months. If the cells are to be used again immediately, it is advisable to save some of the zinc sulphate or colorless solution from the top of the cells. The zincs should be carefully removed from the top of the cells, scraped with a knife or good scraper and washed clean with water. If the solution of zinc sulphate is to be saved, the clear liquid should be carefully siphoned off into a separate jar after the zinc has been removed. The sediment should be dumped where it will do no damage. After carefully cleaning the jar and the copper, replace the copper in the bottom of the jar. Place the blue stone crystals around the copper and pour back the clean liquid, if this was saved for immediate use. Replace the zinc and add water to cover the zinc. If the cell is now short circuited, it will be ready for operation in short order.

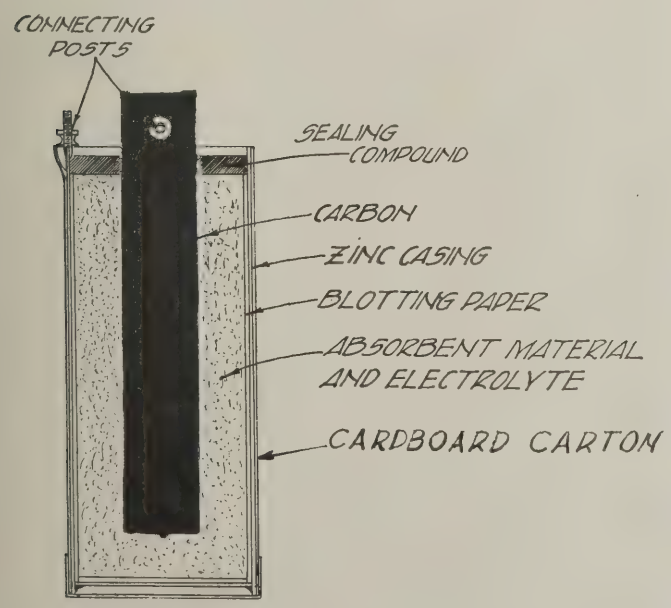


Fig. 3.

If entirely new solutions are used, it is necessary to short circuit the cell at least 24 hours. Fresh solution gives the best results where time and expense are negligible.

Creeping of Salts.

Unless proper precautions are taken when setting up the cells, the jars are soon coated at the top and down the sides with white crystalline salts. These are sulphate of zinc crystals and are from the colorless solution in the top of the cell. Their appearance not only indicates a considerable loss of active material from the cell, but also presents a dirty appearance and when moist may cause a leakage of current between the cells. This is caused by the evaporation of the solution in the top of the cell which leaves a portion of the salt adhering to the side of the jar. This, in turn, on account of capillary attraction, acts the same as a lamp wick and draws more of the solution up, which in turn dries and continues the operation until the deposit reaches the base of the outside of the jar. In case that adjoining jars touch each other in this condition, or if they are resting on a damp support, this deposit acts as a conductor, producing a leakage of current which is wasted and runs down or exhausts the battery, besides preventing the cell from giving its full voltage to the circuit.

To prevent evaporation and creeping of the salts, it is advisable to cover the solution with a small amount of pure mineral oil. This should be free from naphtha or acid, and have a flashing point over 400 degrees Fahrenheit.

The trouble which may arise from the use of oil in this manner is that it may rot the insulation of the wire, which runs to the copper plate. For this reason only a good quality of petroleum lubricating oil or heavy paraffine oil should be used.

Fig. 2.

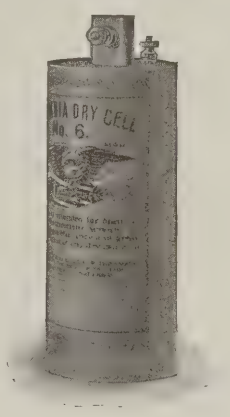


Fig. 4.

If it is intended to coat the top of the jar with melted paraffine, dip the inverted jar about ½ inch to one inch into melted paraffine, tipping the jar sidewise to admit air so the paraffine will go up inside the jar.

In case the proper shaped dish cannot be secured in which to melt the paraffine, a deeper dish can be used, and nearly filled with hot water. The paraffine can then be placed on the water as they do not mix. Then heat the water until the wax melts. When the tops of the jars have been coated, allow the water to cool. The wax will harden and turn white when cold, and it can then be readily removed.

DRY CELLS.

This name is applied to cells in which the solution or electrolyte is held by some absorbent material and sealed so that it may be placed in any position without spilling the electrolyte or interfering with the operation of the cell. A large variety of compounds and absorbent substances are found in the various makes of dry cells on the market, as each manufacturer has something special which he claims to be superior to others, and whose composition is carefully guarded as a trade secret.

Dry cells are used principally for open circuit work; that is, on circuits which do not require the use of the battery but a small part of the time, allowing the battery to rest or recuperate for the remainder. For example: telephone transmitters or talking battery; bell or buzzer systems; gas or gasoline engine sparking, both stationary and portable; testing circuits.

Common types of these cells are shown in Figs. 2 and 4. A sectional view is shown in Fig. 3, showing some of the details of construction of a common dry cell.

The elements, zinc and carbon are generally used, and form the containing case or zinc cup and the carbon pole or center terminal, respectively. A cardboard jacket or carton, which fits over the zinc cup, is used to insulate the cells from each other when placed together.

The absorbent material used to fill the space between the carbon and the cylindrical zinc may be mineral wool, saw dust, blotting paper, asbestos, plaster, etc. This absorbent material is soaked with the electrolyte or exciting liquid, such as sal ammoniac, zinc chloride or common salt, depending upon the type of cell and mixed with the depolarizing substance.

On account of the fact that hydrogen gas is given off when chemical action takes place between the materials used, it is

necessary to use some depolarizer to absorb this hydrogen. The compound manganese dioxide is quite generally employed for this purpose. It also tends to lower the internal resistance of the cell, thereby giving a higher short circuit test which will be explained later. It is essential that any gases formed should be absorbed, as the cell is sealed up air tight by means of some resinous compound, which also prevents the evaporation of the electrolyte.

The amount of electrolyte is very limited, as the absorbent material occupies a considerable amount of space. For this reason it is extremely important that the sealing should be perfect, as otherwise the water of the electrolyte solution would evaporate and there would be practically no action between the electrolyte and the dry mixture.

The sealing compound many times becomes cracked by handling or contracts by age, so that cells after being kept on the shelf for a length of time like a year are apt to give almost no current reading when tested. They may sometimes be reclaimed when apparently exhausted by merely drilling a small hole in the sealing compound and adding a small amount of water or sal ammoniac solution. If this is done the hole should be resealed.

In all dry batteries the zinc is known as the negative terminal or anode and the carbon or center connection as the positive terminal or cathode. The voltage obtained from fresh dry cells varies from 1.3 to 1.6, but about 1.5 volts is a fair average.

A common method of testing dry cells is to connect an ammeter across the terminals which gives the short circuit reading. This instrument should not be kept on the cell longer than is necessary to obtain the desired reading, as it is a very severe drain upon the cell. The short circuit test should be used merely to determine the condition of a given type of cell when the short circuit current of this particular type is known and not for a comparison between different types or makes. The short circuit test may show from 12 to 30 amperes. This test is apt to be misleading if the quality of a cell is to be determined entirely by this ammeter reading, as the real value of a dry cell is determined by the length of service which it will give under operating conditions. This depends very largely upon the ability of the cell to recuperate from a given drain. This drain may be in the nature of a telephone conversation or the operation of a bell and the recuperation takes place after the circuit is again opened by hanging up the receiver or releasing the push-button of the circuit. A high initial reading on the ammeter is obtained by adding material to the compound surrounding the carbon, which would lower the internal resistance, but which would tend to shorten the life of the cell. The dry cell manufacturers are aware of the fact that the layman is most apt to buy the battery which gives the high test on short circuit, regardless of the length of service, and so construct their cells as to give this high initial reading. This quality may be useful for some classes of work, but the relative value of different types should be based upon their length of life under actual service conditions.

A test which approximates service conditions could be made only by connecting the different types to be tested, to some mechanism which would automatically close their circuits through the same resistances for the same periods of time, and then determine their value after a given time has elapsed. The circuits through which they are to be connected for test should be as nearly as possible like those of the circuit on which they are to be used.

Care should be exercised in locating them in a dry place, as the cardboard jacket is liable to absorb moisture, causing the zinc case to corrode, and also producing appreciable current leaks that would exhaust the cell. When a large number of them, like 100 cells or more, are used to form a high voltage battery, it is well to keep them separated so that they do not touch each other. This may be done by using a battery cabinet provided with thin wood partitions between the individual cells.

On account of their small cost, it is impracticable to renew the ordinary dry cells, so that they are thrown away when exhausted.

Defective cells may often be detected by breaks in the sealing material or by spots in the zinc can which have been corroded, either from the action of the chemicals in the cell or by substances which have come in contact with the cell from other sources. The presence of these corroded spots may be detected many times by damp spots on the cardboard carton encasing the cell.

When installing them on a circuit it is well to mark the date on the cardboard, as this information may be useful later.

Their being very compact, requiring no attention after once connected, having no gases to corrode nearby material, nor liquids to spill out and the simplicity with which they are connected, especially fits them for many purposes for which the wet cells could not be applied, such as for telephone service and many types of flash-light batteries, etc.

PROBLEMS.

Editor's Note—The Pennsylvania Railroad has objected to our publishing the answers to the problems as was announced last month, and we will therefore abandon the idea. If, however, there is any question on any of the problems, write us, and we shall be glad to help you individually.

First Lesson.

1.—Of what do the elements of a gravity cell consist?

2.—What is the difference between the elements and the electrolyte in the gravity cell?

3.—What are the indications that the solution or electrolyte is in good condition?

4.—What precautions are taken to prevent the deposit of crystals on the outside of the gravity cell?

5.—What two methods can be employed to secure prompt action of the gravity cell shortly after setting it up?

6.—Give two or three reasons for the gravity cell not being adapted for telephone work.

7.—What happens in the cell in case that the blue solution comes in contact with the zinc in top of the cell?

8.—Why is it not just as practical to have a small generator in place of so many primary batteries?

9.—Why is it necessary to protect the wire leading to the copper plate in the bottom of the gravity cell with a rubber insulation reaching above the solution?

Second Lesson.

10.—In what respect do the Edison and Gordon cells differ from the gravity cells when making renewals?

11.—What care should be taken to prevent breaking the jars when renewing Edison or Gordon cells?

12.—What provision is made with the Edison and Gordon cells to prevent creeping of the salts?

13.—(*a*) What is meant by polarization? (*b*) Is this a characteristic fault of the gravity cell? (*c*) How is it overcome in the Gordon and Edison cells? (*d*) How in the dry cells?

14.—For common magneto telephone talking battery which of the foregoing types of cells is especially suited and why?

15.—What tests should be made to determine the relative values of the different types of dry cells?

16.—What tests are usually employed by dealers when selling dry cells and why would they be unreliable, disregarding the probable errors in the small portable pocket instrument usually used for these measurements?

Lesson will be continued next month.

SMALL FEEDER VOLTAGE REGULATORS.

The General Electric Company recently issued Bulletin No. A4129, which illustrates and describes in considerable detail that company's Small Feeder Voltage Regulators. This regulator is of the pole type and is built for use on single-phase feeders only. It is made in two designs, one for outdoor installation and automatically operated, and the other for hand operation, and to be installed indoors only.

This bulletin contains internal and external views, connection and dimension diagrams.

The National Tube Company, Pittsburgh, Pa., announces that commencing August 1st, 1913 they shall enter the electrical conduit field. They have contracted with the National Metal Molding Company and the Safety-Armorite Conduit Company, both of Pittsburgh, Pa., to manufacture and sell this product for them as their agents, under their various brands. They will also sell this product on the "Pittsburgh Basing Discount" plan in the same manner as all wrought pipe for other purposes has been sold for the past thirteen years.

A mailing folder showing 43 designs of glass insulators has just been sent us by the Brookfield Glass Co., New York City. Many of the designs are new. The folder will appeal to anyone who uses insulators.

LESSON 19

MATHER AND PLATT (EUROPEAN SYSTEM).

Although to the best of our knowledge this system is not installed in any American cars, it contains a good many points of interest and may offer valuable suggestions to car lighting men in America in improving our own service. Like all other equipments it employs an automatic switch having a series and shunt winding. The operation of this is identical to that previously explained on some of our own systems, but there is a bottom contact as shown by the wiring diagram, Fig. 111, the function of which will be explained later.

There is no regulator required in this system as the regulation is effected by the dynamo itself, the battery existing more for the purpose of supplying light when the train is at rest or running below cutting-in speed. The dynamo output can be adjusted to any desired value by shifting the three contact points on the resistance (O. A.). This resistance (O. A.) has eleven terminals, on any one of which the three movable connections, (F. L.) (H. L.) and (N. L.) may be fixed. These are connected to the main "barrel switch" shown at the bottom of the panel in Fig. 110 and are brought into operation by the latter according as it is turned to the full light, half light or no light position. With no lights on the connection will be made at (N. L.) and all the resistance (O. A.) would then be in series with the generator field, with full lights on the contact would be made (F. L.) and all this resistance would then be cut out of the generator field, and with half lights on (H. L.) contact would be made which would insert one-half of the resistance (O. A.).

By knowing the probable amount of discharge at stops the three contacts may be adjusted to such a value as would provide proper charge for the battery as explained in Lesson 8. The lamp resistance (L. R.) is made in two sections, for full lamp

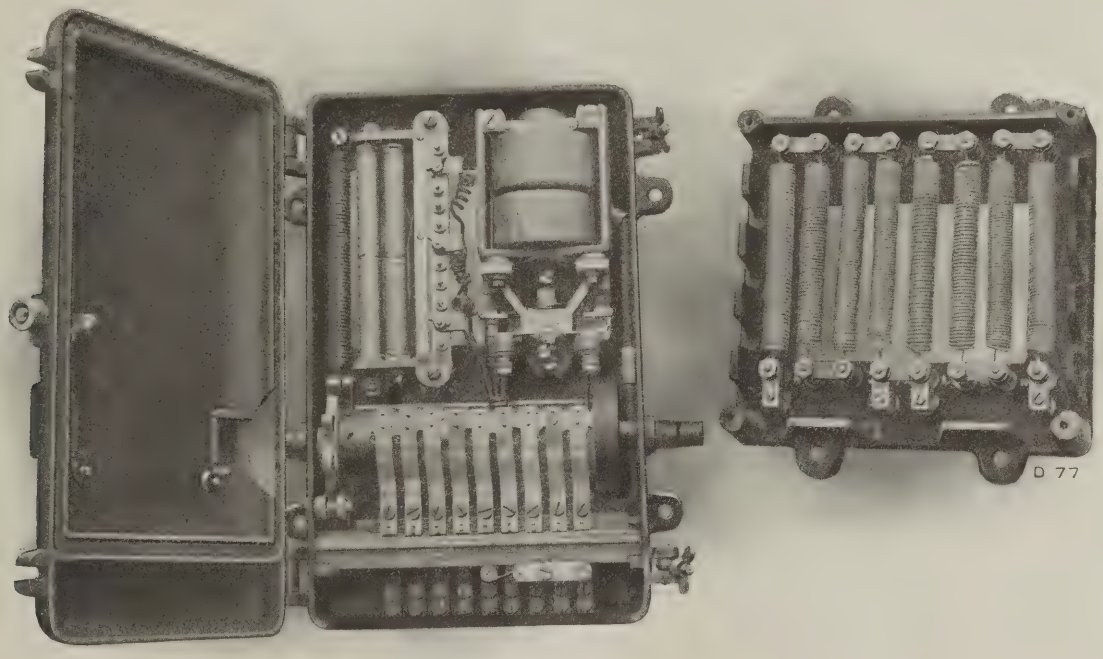


Fig. 110. Switch Panel and Lamp Resistance Grid of Mather & Platt System

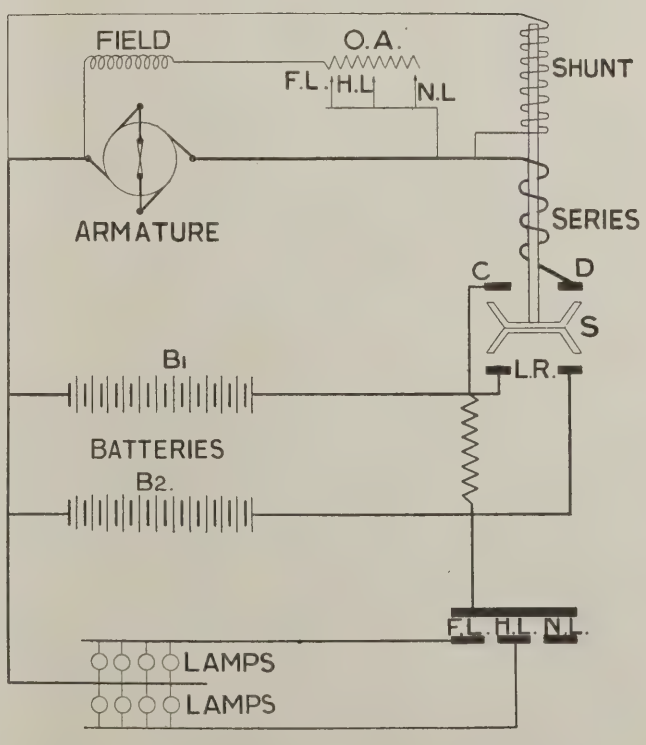


Fig. 111. Wiring Diagram of Mather & Platt System

load and half load. These may be operated by the main barrel switch as in the case of the output adjuster. On no lights they are short circuited altogether, and on half lights one section is brought into use, and on full lights the other section is connected in parallel with the first. This is done so as to provide the same voltage drop in the resistance with full lights or half lights.

It will be noticed that the lamp resistance (L. R.) is connected between the positive terminals of the two batteries, and when the generator is operating the positive of one of these batteries connects direct to the point C. of the automatic switch, and the positive of the other battery connects directly to the lamps. This then provides that one of the batteries will be used merely as a regulating battery, the other absorbing the greater portion of the charging current. At stops the lower contact of the automatic switch short circuits this resistance and connects together the positive terminals of the two batteries. In order that both batteries should receive the same treatment, as near as possible, they are automatically interchanged by a contact on the main barrel switch which operates every time the lamps are switched on.

The Generator

This generator is of a peculiarly novel design and is known as the "Rosenberg" generator. A modification of this generator was described in our April issue in connection with our article on the new car lighting equipment of the Electric Storage Battery Company. It has two special features which no other dynamo seems to contain. (1) the output of the generator is maintained constant by certain magnetic reactions within the dynamo itself. In other words it is a self regulating dynamo; (2) the polarity of the machine is automatically maintained the same, whether the train is moving forward or backward, so no pole changing is required with this dynamo.

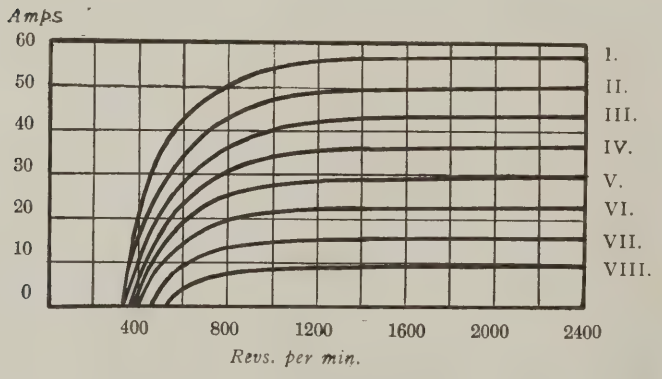


Fig. 112. Curves Showing Generator Output at Various Speeds and Various Settings

The generator is essentially a constant current machine, delivering practically constant current at all train speeds above nineteen miles. The automatic switch closes at about nine miles per hour, and at this time the generator delivers only a small amount of current to the battery. This current output gradually builds up as shown by the curves in Fig. 112, until at an armature speed of about 700 it attains a maximum.

The wiring diagram of the generator connections is shown in Fig. 115. It will be noticed that there are four brushes on this machine, the two brushes (bb) at which point the brushes of an ordinary machine would be placed, (midway between the poles) are completely short circuited and the current for the external circuit is taken from the brushes (BB) located in the diagram, directly under the pole shoes. The primary field winding (ff) however, is of comparatively small value, so the voltage generated between the brushes (bb) is low. This is sufficient however, to cause a short circuiting current to circulate from the positive (b) brush through the short circuit to the negative (b) brush, thence back through the armature coils to the positive (b) brush. This short circuiting current through the armature coils creates a heavy flux of magnetic lines in a horizontal direction which pass from the armature into the "S" tips of the heavy pole shoes, thence through these pole shoes to the "N" tips and back to the armature.

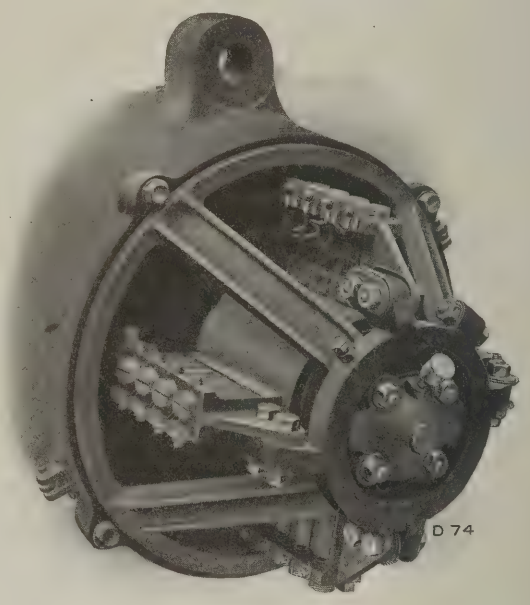


Fig. 113. Commutator of the Rosenburg Generator

This magnetism generated by the short circuiting current in the armature, is the main magnetic field of the generator, and as explained above this does not pass around through the generator frame as the field magnetism does in ordinary generators, but simply flows through the pole shoes and armature as explained above.

If, for the sake of clearness, the two currents flowing through the armature, (1) the short circuited current, and (2) the current for the external lamp or battery circuit, be considered as two separate windings, it will be observed that whereas the current flowing through the short circuiting brushes (bb) produces a magnetic flux at right angles to the primary flux of the coils (ff) and therefore produces no effect on this latter flux as regards magnitude, the current flowing through the brushes (BB) produces a magnetic flux which is exactly opposed to the primary magnetism of the coils (ff) and accordingly diminishes it in exact proportion to the strength of the current in the external circuit.

It follows, therefore, that for a certain value of the external current the ampere turns of this current in the armature will exactly correspond to the ampere turns of the primary exciting winding, and being equal and opposite, the resultant magnetizing flux would be zero. But without a primary flux, the dyna-

mo would cease to generate current, so it is clear that the limiting value of the external current which the dynamo can produce is that current which makes the ampere turns of the armature coils equal to the ampere turns of the primary field windings (ff). Further, a very small excess of field ampere turns over armature ampere turns is necessary to generate sufficient voltage across the brushes (bb) in order to cause the proper short circuiting current, which generates the main magnetic field of the machine, to flow.

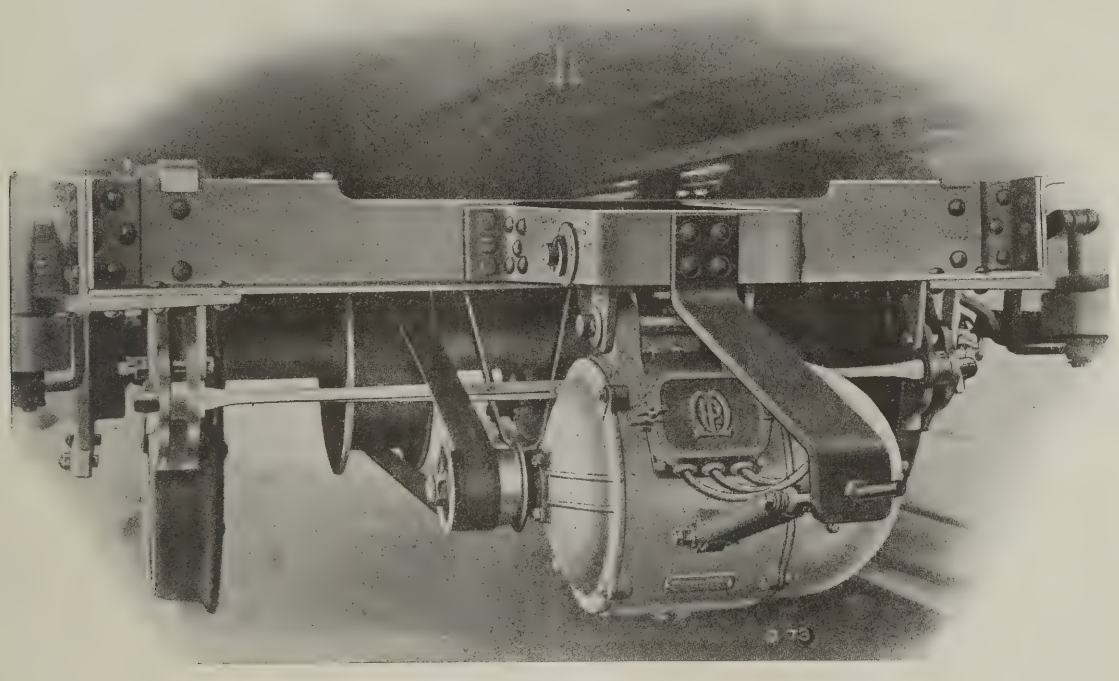


Fig. 114. Showing Suspension of Rosenburg Generator

A numerical calculation will probably make this point clear.

At normal speed a short circuiting current equal to about 40 per cent of the external current is sufficient to produce a proper working flux, and for this current an excess of field ampere turns over armature ampere turns of 10 per cent only is required. Now if the speed changes to four times normal value, the

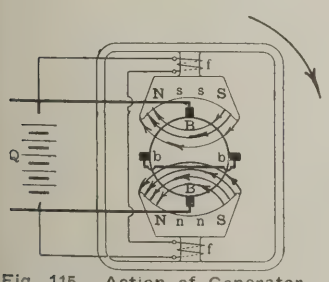


Fig. 115. Action of Generator Right-Hand Rotation

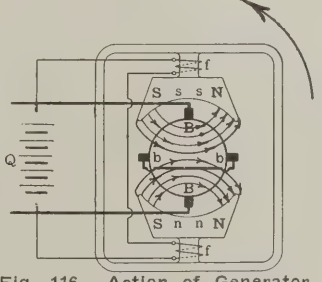


Fig. 116. Action of Generator Left-Hand Rotation

current cannot increase by more than 10 per cent, for a 10 per cent increase would entirely neutralize the primary flux. On the other hand, if the speed falls to say, 70 per cent of the normal value, the current would fall; but should it fall for even as little as 10 per cent of its normal value, the primary flux would immediately be doubled producing a rise in the short circuiting current, which produces the main magnetic field, of about 40 per cent, thus almost exactly compensating for the drop in speed. The fact that the compensation for speed variation depends upon the differential action of two practically equal quantities is the reason for the very accurate regulation which is obtained in this dynamo.

The effect of reversing the rotation of the dynamo is shown by referring to the diagrams Fig. 115 and Fig. 116. Since the direction of current in the primary exciting winding remains unchanged, the polarity of the short circuiting brushes (bb) reverses when the direction of train motion reverses. As the current flowing through these brushes creates the main magnetism of the machine, a reversal of train motion will then cause a double reversal in the dynamo, (1) reversed direction of rotation of the dynamo and (2) reversed magnetic field, so that the polarity delivered by the brushes (BB) is always the same whatever be the direction of motion.

The curves 1 to 8 in Fig. 112 show the rise in the current output of the machine with rising speed, when the dynamo is connected to a battery of constant voltage. These curves show the different outputs of the generator which are obtained with the various exciting currents in the primary field winding (ff). Curve No. 1 represents the output of the machine with maximum excitation, and it will be noted that at 340 revolutions, corresponding to a train speed of about 9 mi. per hr., the terminal voltage of the generator becomes equal to the battery voltage. From that point the current supplied by the generator increases very rapidly with an increase in speed. When a speed of about 700 r. p. m. or 19 mi. per hr. is reached, the current attains nearly a maximum. A further change from 800 to 2,400 r. p. m., twenty-one to sixty-five miles per hour, only produces a rise in current of about 12 per cent. The short circuiting current flowing through the small brushes (bb), although comparatively heavy when the automatic switch first closes rapidly falls to a low value at high speed. In order to prevent this short circuiting current from reaching a danger-

ous value at low speed, the magnetic circuit through the pole shoes and armature is so designed that the saturation point is reached at a value corresponding to the maximum safe short circuiting current. Then if the generator speed falls below that corresponding to this point, the short circuiting current will decrease until finally the voltage of the machine will fall below that of the battery.

Although the magnetism due to the short circuiting current flow through the armature is the principal magnetism of the machine, the primary flux magnetism, at right angles to it, has the effect of causing the resultant of the two fields to be inclined at a slight angle, the direction of this inclination being opposite to the direction of rotation of the armature. The effect of this inclination is to give the main brushes a forward lead, or equivalent to the action of a commutating pole.

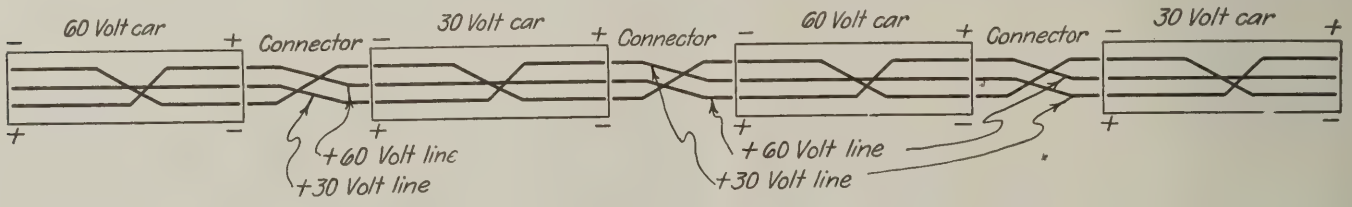
Practical Stunts

We pay $1.00 for each of the practical stunts published in this section. Send in your ideas—in your own words and with just a rough pencil sketch if necessary.

Train Lining 60 Volt and 30 Volt Cars.

It often occurs that a train is made up of some cars with 30-volt axle equipment and some cars with 60-volt axle equipment; where it is necessary to train-line the various equipments together, this can easily be done by the following method:

The accompanying diagram shows the four cars, two of which are 30-volt and two 60-volt cars. By shifting the connections of the connectors, as shown in the diagram—that is, running from positive to neutral and from neutral to positive in each case—the 3-wire train line is then changed into two simple 2-wire circuits having the negative as a common return wire.



Wiring Diagram for Train Lining 60 Volt and 30 Volt Cars Together

It will be noted that in the 30-volt car, the 60-volt positive wire occupies the neutral train line and in the 60-volt cars, the 30-volt positive wire is in the neutral position.

This scheme can be applied to any combination of cars, as desired. Where two cars of the same voltage come together, however, the standard 3-wire connector, neutral connecting to neutral, must be used.

W. M. Wiggins.

Easy Way to Remove Rubber Jars Sealed in Tray.

It is the practice on our road to seal rubber jars in a home-made wooden tray. When it becomes necessary to remove the jar from the tray, due to acid destroying the wood or other causes, much care must be exercised or the rubber jars will be broken.

If these trays are to be dismantled they are first placed over some heating coils where they will get fairly warm, or warm water or steam is turned into the jars, which will soften the rubber somewhat so that it becomes less brittle, and a cold chisel can then be driven between the center end partitions and the sideboards of the tray. The ends can then be split across, taking about one inch of the wood at a time. In California we simply place the trays in the sun for a while in order to warm them up.

John Webber.

Prize Question Box

Announcement.

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

This ought to stir up some mighty interesting information, for we can all ask questions even though we don't have a big line of practical stunts to submit.

The names of the prize winners will be published each month and all the questions submitted will be answered by us in the same issue. (If we can't answer them ourselves, we will find somebody who can.)

Better send in your questions now, while you think of it.

First Prize

Reversed Cell in Car-lighting Battery.

To the Editor:

Q. How is it that one cell in a carlighting battery can become reversed when all other cells in the battery which receive the same charge and discharge seem to be in good condition? —L. B. K.

Ans. A reversed cell is usually caused by local discharge of that particular cell. This may be due to any of the following causes: sediment so deep that it touches the bottom of the plates, lead tree formation between any positive and negative plate, impurities in the electrolyte such as copper or iron, local grounds, etc. Any one of these troubles will cause that particular cell to slowly discharge all the time, the lead tree, sediment or grounds acting as a short circuit across the terminals of that particular cell. It will then slowly discharge all the time, whether there are any lamps turned on or not.

After standing for a sufficient length of time that particular cell will become completely discharged and its voltage fall to zero. When the lamps are then turned on, the other cells of the battery being up to full capacity, deliver their full normal voltage and normal discharge current flows through the battery to the lamps. This current, however, is forced through the discharged cell mentioned above, as it is in series with all others. Both positive and negative plates of this cell have been converted to lead sulphate by the short circuit mentioned above, or by copper or iron impurities in the electrolyte, and the discharge current flowing through this dead cell acts as a charging current insofar as this particular cell is concerned.

This is exactly similar to what would occur if a cell is charged in the wrong direction—the plates finally become reversed, and what was normally the positive plate then becomes negative, and what was originally the negative plate is then positive.

Such a reversed cell in a battery has a double effect on the battery voltage; it not only does not contribute

its voltage of two volts as do the other cells of the battery in making up the total battery voltage, but it actually bucks the battery voltage down another two volts, so that such a reversed cell in a battery reduces the battery voltage by four volts.

Editor.

Second Prize

Reversing Connections to Series Solenoid of Regulator.

To the Editor:—

Q. Does it make any difference in the operation of a constant current regulator such as the Consolidated type A or any of the later equipments having a series regulator winding, if the current is passed through the regulator coil in a reversed direction, that is, if the coil is connected up wrong?—W. M.

Ans. Provided the plunger of the solenoid is a bar of soft iron which has little or no permanent magnetism of itself, it will not make any difference in the operation of the regulator if the current is passed through a series coil in a reversed direction. Magnetic lines always attract soft iron whether it be magnetic lines from a north pole or magnetic lines from a south pole. So the plunger of soft iron will be pulled upward into the solenoid with exactly the same force whether the direction of flow of magnetic lines is downward or upward through the center of the coil.

If the plunger of the solenoid were a piece of hard steel, (this is never used in carlighting equipments) the plunger might be actually forced out of the coil with a weak current flowing through the series coil. Even under such conditions however, if the current through the solenoid rises to such a value that the magnetism of the solenoid greatly overpowers the permanent magnetism of the plunger, it will draw the plunger into the coil.

This line of argument does not apply at all to compound solenoids where both shunt and series windings are employed, the magnetism of which act on the same piece of iron, as in an automatic switch. Here the series coil must be connected properly or it will oppose the magnetism of the shunt coil when the automatic switch closes and cause the switch to drop out immediately after closing. Editor.

Third Prize

Head-end Troubles

To the Editor:

Q.—The other night when we were lighting an eight car train, and everything seemed to be O. K. I pulled down the connector to the mail car ahead of the dynamo car, and all lights went out, but when I put in the run around switch the entire train lighted up again. We have done this same thing for months with the same number of cars in the train and under the same conditions, and pulling down the connector had no effect on the lights whatever. What was the cause of these lights going out at this particular time?—E. A. D.

Ans. This looks as if the rear loop of the train were open, and the loop at the forward end of the mail car closed so that all the lamp load of the entire train fed through the center train line of the mail car thence through the loop at the forward end of the mail car to the lamp negative train line. If the rear loop of the train line were properly closed and there was no other connection from the generator negative train line to the lamp negative train line, as it should be, this trouble you speak of could not have occurred.—Editor.

Q.—I operate a Union Pacific dynamo car and the other night when I started up it generated O. K., raising the voltage to 63 volts, but as soon as I put the circuit breaker in it immediately kicked out. I tried this several times with the same result. The lamp load could be carried from either the battery on the dynamo car or the C. & N. W. terminal station line. When I tried to cut in the turbo-generator set, however, the breaker would kick out every time.—E. A. D.

Ans. This looks as if there may have been something wrong with your volt meter. If this had been as much as five or ten volts off, the extra load thrown on the generator by having it so much above or below the battery voltage would cause either such an excessive charging current, or discharge current (running the generator as a motor) that it might kick out the generator breaker.—Editor.

COMMUNICATION ON BALL BEARINGS.

To the Editor:

There are two or three points in connection with the article I furnished for your June issue which may prove somewhat misleading when considering ball bearings in carlighting service. The results of the tests as given in Paragraph 3 page 28 of the June issue were made to determine the effect of increasing the number of balls in a bearing. The relatively small mileage indicated by these tests might possibly be construed by some as the probable mileage to be obtained with this bearing in carlighting service.

These tests were run on a No. 207 standard annular ball bearing having a rated capacity of 600 pounds at 500 r. p. m. as will be noted from the table given in this article the bearings under tests were subjected to a load of 3,100 pounds, this being over 500 percent overload, and were run at a speed of 1,080 r. p. m. which is more than 100 percent over speed.

At the time these tests were run three foreign bearings of the same size were tested under the same conditions of load and speed. The results secured from the tests of these three foreign makes of bearings were as follows:

Bearing	Load	R. P. M.	Average Mileage
Foreign Bearing "A"	3,100	1,080	1,286
Foreign Bearing "B"	3,100	1,080	460
Foreign Bearing "C"	3,100	1,080	1,394

In further explanation of the low mileage secured on these tests we would like to have it made clear that the life of the bearings runs up very rapidly as the loading is decreased to rated load, or to loads below rated capacity. As an indication of the truth of this statement, we may say that S. R. B. Annular Ball Bearings have operated a distance of 150,000 miles or approximately 88,500,000 revolutions without failure, at rated load and rated speed. This mileage, however, has been secured only with S. R. B. Bearings, the best distance we have ever been able to secure from foreign bearings being approximately 44,000,000 revolutions under the same conditions.

On page 26, column 2, where it is stated that balls examined by the United States Bureau of Standards were found to vary only from one-quarter to one-half of one-thousandth of an inch in diameter and sphericity, this should have read "Balls taken from a stock S. R. B. Bearings by the United States Bureau of Standards were found by the Bureau to vary only from one-quarter to one-half of one-ten-thousandth of an inch in diameter and sphericity."

J. G. Cooley,
Mgr. Ry. Dept., Standard Roller Bearing Co.

Motor Talk No. 10

Alternating Current Motors (Continued).

Synchronous Motors have been used for years to drive generators, as parts of motor-generator sets, and for a few other purposes requiring constant speed regardless of load, but their field has been comparatively limited until within the last few years. Naturally, people have looked upon all motors simply as a means to apply power for driving some machine or other, and have usually bought motors for that purpose only. But, the rapid increase in the application of induction motors (for power purposes requiring but moderate speed variations) has brought the synchronous motor to the front as a means for improving the power factor of the system while doing other useful work.

Before going further into the operating characteristics of synchronous motors, let us first consider construction and see wherein they differ from other alternating current motors. In the course of these "Motor Talks" it has been stated that any generator may be operated as a motor, and that is true, although slight changes of connections are sometimes necessary. For instance, in order to use a compound wound direct current generator as a motor, it is necessary to reverse the connections of the series field coils in order that they will tend to increase the field strength (and consequently the starting torque) instead of opposing the shunt field and having the reverse effect. Synchronous motors are essentially alternating current generators properly modified for operation as motors but require more complex treatment.

In order to make this matter clear and easy to follow, let us first consider direct current apparatus a bit and see what happens. If a direct current generator is being driven at no-load and no current flowing in the armature, it will require very little power to operate at full steed. But as soon as a load is put on the generator and current is caused to flow through the armature, more power will be necessary to drive it. In fact, if the speed and field current are kept constant, the power required will be almost directly proportional to the armature current. This is because the armature core is magnetized by the current passing through its windings, the strength being proportioned to the current, and the reaction between the armature poles (thus formed) and the field poles tends to keep the armature from moving. So, in order to force the armature to rotate against this magnetic pull, it is necessary to apply more driving power.

Since this pull or reaction is in the opposite direction to the rotation of the armature, it stands to reason that if power is applied to the field and armature of this same machine from some other source (and in the same direction through the windings) that the interaction mentioned will cause the dynamo to operate as a motor, but with the armature rotation reversed.

It should be remembered that, when the current passes into the armature of any motor with a commutator, definite magnetic poles (north and south) are formed in those portions of the core which are surrounded by the live coils, similar to the field coils, and it is the attraction and repulsion between these poles and the field poles, as well as the effect of the current in the armature coils, that causes the rotor to move. As the armature turns, the commutator causes the current to flow through the next set of coils, etc., and the magnetic poles of the armature always shifting to the proper relation with the field poles, otherwise there would soon be no rotation. All of the negative armature poles would be attracted by all of the positive field poles and the movement stopped.

In other words, the action of the commutator is to cause the current to flow one way through the armature coils when passing the north poles of the field and in the opposite direction when passing the south poles, thus really subjecting the armature windings of the motor to an alternating current. If slip rings are placed on the rotor of a motor instead of a commutator, and an alternating current applied, it will rotate all right, but, the rotor must first be brought up to such a speed that the reversals of armature magnetism will occur with proper relation to the poles of the stator or field. If this is not done there will not be the proper interaction, as previously mentioned, and consequently no rotation. There will be merely an oscillation of the rotor back and forth between the north and south poles of the field.

Synchronous motors are practically machines with fixed field poles and alternating armature poles as just described, so such a machine can be run as either a generator or as a motor. Alternating current generators have their fields excited with direct current in order that the polarities will be fixed and constant, so, when run as synchronous motors the field requires direct current excitation in the same way. This is one reason for their unpopularity. To be sure, this direct current may be obtained from a rotating armature (as is done with self exciting a.c. generators) by means of a commutator, but is usually obtained from a separate source. This applies to machines with rotating fields and stationary armatures as well as those with stationary fields and rotating armatures. Large synchronous motors usually have rotating fields.

Perhaps it would be well at this point to explain why motors of the type under discussion are called "synchronous" motors. It is well known that when each coil of the armature of a generator passes a north pole of the field that a current is caused to flow in one direction, and when this same coil passes a south pole the current is caused to flow in the opposite direction. This total set or cycle of operations multiplied by the number of pairs of poles on the machine will give the number of cycles or the "frequency" per revolution of the armature. And, the number of cycles per revolution multiplied by the revolutions of the armature per second determines the frequency of the generator, because it is always stated in "cycles per second."

The word "synchronous" means practically "happening at the same time as something else," and as applied to motors it means that the armature poles are passing the field poles at the same "frequency" as those of the a.c. generator which feeds the line. Since

the frequency of any alternator is found by multiplying the number of pairs of poles by the revolutions per second, it follows that the speed of a synchronous motor (in revolutions per second) will be equal to the frequency divided by the number of pairs of poles. To get the speed in revolutions per minute (r. p. m.) it is only necessary to multiply this by sixty.

Synchronous motors will run at this fixed speed regardless of load up to the point where they are "stalled" or stopped by the overload. Sometimes the rotor will slip or drop back an amount equal to the distance between positive poles, if heavily loaded, but will then run in exact synchronism again. This makes them especially valuable for driving generators for service requiring constant voltage or for machines requiring fixed speeds, but they must be started without load.

One of the most valuable uses of synchronous motors is to improve the power factor of the circuit. It is well known that induction motors cause a lagging current in the line, that is, their inductance causes the current to get out of phase with the potential and impose a useless load on the generators. Owing to a peculiar characteristic of the synchronous motor it is possible to cause a "leading" current to flow in the line, so it is now customary to put at least one synchronous motor on lines feeding an inductive circuit. This effect is obtained by "over-exciting" the fields of the synchronous motor, and when used for this purpose it is called a "synchronous condenser."

The construction of synchronous motors is practically the same as alternating current generators, and they are started in a similar manner to other a.c. motors. They are usually polyphase, mostly three-phase, and autostarters or compensators may be used, although separate, small motors are frequently used for starting large machines. Sometimes they are started as induction motors by special connections.

The New General Office Building of the Union Pacific Railway Company

The general departments of the Union Pacific Railroad Company have taken possession of their new home in the recently completed general office building in Omaha, Nebraska, and are now housed in a manner befitting the magnitude of the company's operations.

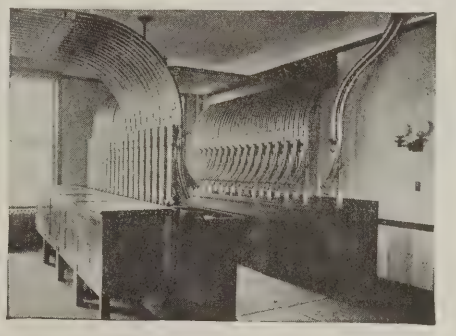
The building, which is located at the northeast corner of Fifteenth and Dodge Streets, has twelve stories and a basement. It is 173 feet high, with a frontage of 199 feet on Dodge Street and 146 feet on Fifteenth Street, with a 50 foot court in the rear. The construction is of the most modern skeleton steel frame work type, with polished concrete floors and tile partitions, rendering the building thoroughly fire-proof. Maine granite is used for the base, the exterior of the first three stories is of Bedford stone, while the upper stories are of gray

New U. P. Headquarters at Omaha

pressed brick with terra cotta trimmings of the same color. Interior fittings are of Colorado marble and early English finish oak. The entire building cost approximately $1,400,000.00.

All the modern conveniences and necessities to be found in the modern office building have been installed. The equipment includes seven electric passenger elevators; one electric freight elevator; a filtering and refrigerating plant for furnishing pure and cool drinking water throughout the building; a vacuum system for cleaning without raising a particle of dust; a sprinkled air (warmed in cold weather) ventilating system; thermostat heat regulation in all offices; and automatic fire pumps.

Throughout the building there are a number of vaults used by various departments for current files. Besides these, there are also forty-eight commodious, well ventilated and well lighted fire-proof vaults in the basement for safeguarding the permanent records.



Pneumatic Tube Terminal Room

Telegraph Department.

The Superintendent of Telegraph, Mr. J. B. Sheldon, who has been in charge of the telegraph and telephone lines of the Union Pacific for a number of years and has been the moving spirit in promoting the general efficiency of the personnel under his supervision, has had the direction of the work entailed by the transfer to the new quarters. It is probably due more to his executive ability and zeal than to any other factors that a high standard of efficiency has been maintained at all times on the telegraph and telephone lines of the road. It is also due to his foresightedness that all of the equipment installed is of the most modern obtainable. Mr. Sheldon is fortunate in having under him a capable staff, consisting of A. O. Nichols, Chief Clerk; John Hilbert, Engineer; and P. F. Frenzer, Manager in Charge of Local Operations.

The telegraph department is centrally located on the 4th floor, facing Dodge Street. The superintendent's quarters comprise private offices for the superintendent and chief clerk, and a well lighted and well arranged general office, with approximately 2,300 square feet of floor space.

Telegraph Operating Room.

The telegraph operating room is 53 feet square, affording ample space for present and future requirements. A commodious locker room adjoins the main office, while lockers are placed near the telegraph tables for the telegraphers' typewriting machines. All furniture and fittings are new and in harmony with the woodwork finish of the building.

Cables and wires are brought into the telegraph office and to the telegraph tables by a complete and comprehensive conduit system, consisting of pipes of various sizes. Approximately 25,000 feet of rubber covered wire is laid in these conduits, extending from the distributing frame to operating, repeater and multiplex tables. This is sufficient to care for all present and future connections.

In addition to the conduits within the office, there are three 2-in. pipes leading from the office distributing frame to the wire shaft, extending up and down between floors, for the main cables coming in from the outside

Mr. J. B. Sheldon, Sup't Telegraph

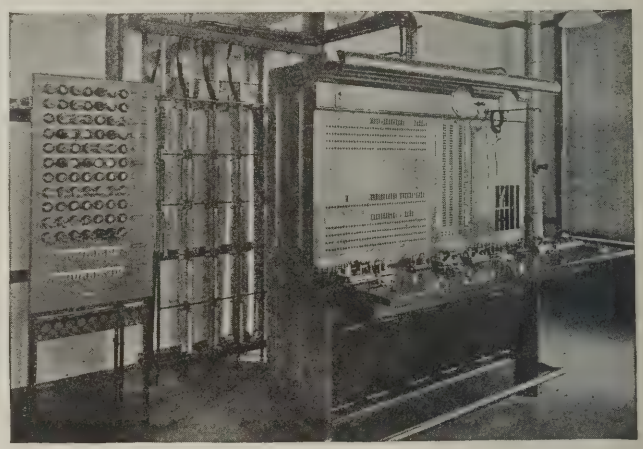
underground; and also three similar pipes leading to the telephone terminal room to carry cables or wires from the telegraph office to other locations in the building.

The operating tables are of solid quartered oak, quartette style, and of special design. Drawers are provided on each side of the various kinds of blanks; and a wire runway extends lengthwise underneath leading to and connecting with the floor conduit, thus affording a convenient and satisfactory way of taking care of instrument wires.

The repeater and multiplex tables are of the standard American Telephone & Telegraph Company pattern and have been furnished by the Western Electric Company, which has also furnished the entire equipment of telegraph and telephone apparatus.

The switchboard is a combination telegraph and telephone Morse board of Western Electric design with special features to meet the Union Pacific's conditions The present capacity of the board is for 40 wires, each carried through 11 jacks. Six are used for making tests and patches in the test panel. The other five are in the Morse panel and are used for cutting in loops to outside offices. Telephone jacks are also provided, the circuits being composited. Composite, simplex or phantom coils may be connected direct to jacks while the leg from each duplex set to operating table is carried through four jacks which have a high insulation resistance value. Four sets of Morse instruments are located conveniently for testing purposes. Under normal operating conditions the board is entirely free of cord and plug connections.

A double scale voltmeter, a combination milammeter and voltmeter, a wheatstone bridge and a galvanometer



Morse and Test Switchboard

together with keys, jacks and plugs complete the equipment required in testing and locating trouble.

The distributing frame, located back of the switchboard, is of the No. 1420 Western Electric type wtih an ultimate capacity of 100 lines and 600 pairs of terminals for local wiring. No. 4-A protectors, which are a combination of heat coils and carbon cut-outs are used.

The coil rack for composite, simplex and phantom equipment is located to the right, back of the switchboard, while a slate base panel is also provided adjacent to the switchboard for resistances, fuses and "time" re-

Telegraph Operating Room

lays. Sixteen time repeater relays are installed, each with contacts for operating two "time" circuits. The contacts are brought out on cords and plugged in at the switchboard at the "time" set for sending out "time" signals over the entire road each day to all offices and for regulating electric clocks at division and district terminal points.

Telephone Message Rooms.

Adjoining the telegraph operating room are two sound-proof telephone message rooms used for handling

messages by composite telephone service. The equipment consists of a table of special design used in connection with a composite switchboard having a capacity of 18 lines. By means of a key, the operator can cut any line through to the private branch exchange for long distance connections.

Pneumatic Tube Service.

A pneumatic tube system consisting of approximately 17,000 feet of three-inch tubing installed throughout the building by the Universal Pneumatic Transmission Company of Chicago, Illinois. It connects with each department and with a central station in the southeast corner of the telegraph room. In and out tubes are provided for each of the thirty-six pneumatic tube stations.

The system is used principally for handling messages to and from the telegraph office, but also serves in delivering correspondence and memoranda from one department to another by transfer carriers at the terminal station.

The pneumatic system is operated on the vacuum principle, the power being derived from a ten horsepower fan motor having a maximum speed of 3,450 revolutions per minute. At top speed it energized the movement of the leather carriers through the tube at

Private Branch Telephone Exchange

the rate of 90 feet per second. Each line is automatically controlled by a globe valve which shuts off power when the line is not in use. Inserting a carrier, opens the valve and allows the air to flow, while delivery of a carrier closes the valve and shuts off the air.

Private Branch Telephone Exchange.

The private branch telephone exchange occupies a room on the same floor with and adjoining other offices of the Telegraph Department. Connecting with it, is a comfortably furnished rest room for the telephone operators.

There are 251 local telephones connecting with the exchange as well as four long distance composite lines. A chief operator and six operators are required for the operation of the switchboard. Service is continuous day and night.

Adjoining the telephone exchange room is a well lighted and well ventilated room in which are installed the terminal frame, storage battery and charging plant used in connection with the telephone exchange.

The Union Pacifice officials in equipping their new general headquarters have spared no expense in bringing together every modern device which could in any way aid in facilitating the work of the various departments and so guarantee a high efficiency for the entire organization. A policy such as this is always profitable in the end, though the initial expense involved may be great, inasmuch as modern time and step saving devices pay for themselves many times over in a comparatively short time in increasing the work capacity of the employees, both rank and file. The well lighted and well furnished offices are also an evidence of the company's desire to make the employees' surroundings cheerful and inspiring. In fact, the new headquarters provide a distinctive model for others to follow from every point of view.

INTERNATIONAL ELECTRICAL CONGRESS, SAN FRANCISCO, 1915.

Preliminary plans for this congress, which is to be held during the week beginning September 13, 1915, in conjunction with the Panama-Pacific International Exposition, and under the auspices of the American Institute of Electrical Engineers, are being prepared by the Committee on Organization. In the week preceding the congress there will be a meeting of the International Electro-technical Commission. The congress is being divided into 12 sections as follows:

1. Generation, Transmission and Distribution.—Central station and sub-station design, control and operation. Long-distance transmission of electric power.

2. Apparatus Design.—Generators, motors and transformers. Prime-movers and their relations. The rating of machinery.

3. Electric Traction and Transportation.—City surface and rapid transit railways; inter-urban and trunk lines; electric vehicles, ship propulsion, mining railways, elevators and hoists.

4. Electric Power for Industrial and Domestic Use.—Factories, mills, refrigeration, heating devices, etc.

5. Lighting and Illumination.—Arc and incandescent lighting; the science and art of illumination.

6. Protective Devices; Transients.—Switches, circuit-breakers; condensers; electrostatics; disruptive phenomena; high frequency phenomena.

7. Electrochemistry and Electrometallurgy.—Electrolytic and metallurgical apparatus and processes.

8. Telegraphy and Telephony.—(a) All communication of intelligence by the use of wires. (b) Electromagnetic waves and radio-telegraphy and telephony.

9. Electrical Instruments and Electric Measurements.—Switchboard, portable, standard and absolute instruments. Testing and standardization methods; absolute measurements.

10. Economics of Central Stations and Systems.—Load factors, power factors and all problems affecting the economy of central stations; also rates and regulation by public service commissions.

11. Electro-Physics.—Radio-activity; Röntgen rays, gas and vapor conduction; electron theory; constitution of matter.

12. Miscellaneous.—Such as history of literature; of electrical engineering; symbols and nomenclature; engineering education and ethics.

In each section it is desired to include as many as practicable notable papers dealing with the status or the progress of the art. Offers of papers and suggestions in this connection should be directed to the Secretary of the Committee on Organization, Dr. E. B. Rosa, Bureau of Standards, Washington, D. C.

ILLUMINATING ENGINEERING SOCIETY.

It has been definitely decided to make the Hotel Schenley the Headquarters of the Illuminating Engineering Society Convention which will be held in

Pittsburgh, September 22-26. This is a peculiarly fitting selection as the hotel is in a popular residence section which is rapidly becoming a civic center. It is in easy walking distance of the Carnegie Museum and Library, Carnegie Technical Schools, University of Pittsburgh, several prominent clubs and the Soldiers Memorial Hall. The last mentioned building will prove of particular interest to illuminating engineers because of the wonderful lighting effects used therein which are said to be unequalled anywhere in the United States.

The program as outlined at the present time covers an exceedingly interesting set of papers on the various subjects pertaining to illumination.

In addition to the technical sessions of the Society, the Local Committee has arranged for a series of entertainment features in which the ladies are included. These features cover golf, tennis, base ball games, automobile rides, theatre and card parties, and conclude with a banquet at Hotel Schenley at which some innovations are promised.

Inspection trips have been arranged to several industrial plants including the Westinghouse Electric & Mfg. Company, Macbeth Evans Glass Company and the Carnegie Steel Company; also a luncheon at the H. J. Heinz Company, the home of the 57 varieties, for the ladies.

The papers scheduled at this time include, among a number of other subjects, the Quartz Light, Fontune, and Neon Tube; also church, factory, store, hospital and street car lighting; the Present Commercial Development in several forms of Lighting, Errors in Photometric Measurement, and the History of Artificial Lighting. In addition to these, a number of others on equally interesting subjects will be presented by authors well known to the engineering profession in illuminating as well as other fields.

The development of the new flame carbon arc lamp will also be discussed by representatives of the manufacturing concerns.

An interesting feature in connection with the technical sessions will be the holding of symposiums on the various general subjects to be led by those particularly well posted on the different subjects. These meetings will afford an opportunity for free and open discussion that it probably would not be possible to obtain in a more formal meeting.

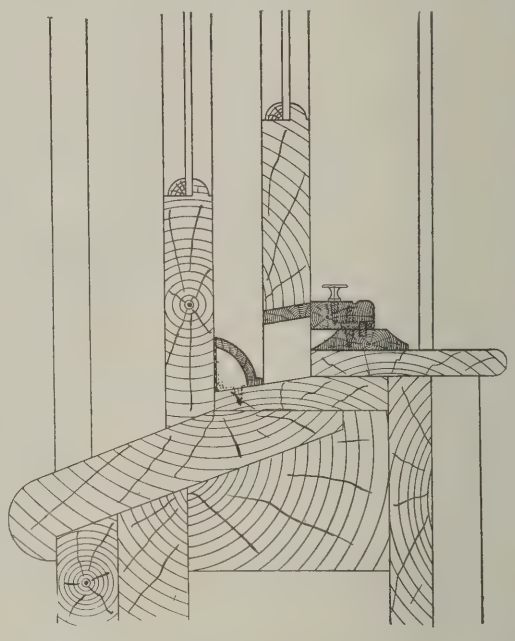
A Transportation Committee has been appointed consisting in part of the secretary of the local section in each city, which will perfect arrangements for the members and friends in obtaining transportation to and from Pittsburgh.

INDIVIDUAL BERTH VENTILATOR.

To meet the long felt want of a ventilator for individual Pullman berths the window attachment shown in the accompanying sketches has been brought out by the B. W. Mudge Co., Chicago, Ill.

It consists of a "quarter-round" running the entire width of the outer sash and hinged in the corner. The "quarter-round" is hollowed out its entire length as shown except for reinforcing sections at intervals. A screen is placed over one edge to keep out cinders. When the ventilator is closed the "quarter-round" folds back between the outer and inner sashes as shown, and when the ventilator is open it rocks forward and the outer sash, after being raised, is let down on top of it.

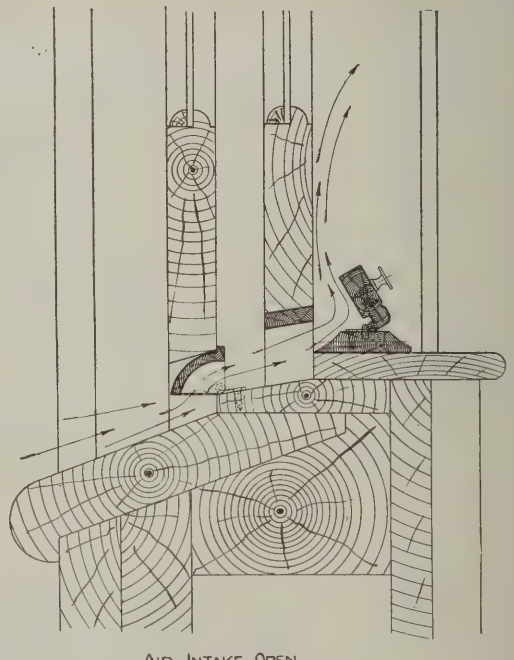
The inside part of the ventilator consists of a strip of wood running the entire width of the window and screwed down to the window-sill. Hinged to this is another strip which ordinarily lies flat snug up against the inner sash as shown closed, and which tilts up to an angle of about 60 degrees as shown open. A tongue



AIR INTAKE CLOSED

and groove along the entire length of these two pieces makes a sufficiently tight joint to keep out cinders no matter at what angle the ventilator may be raised.

To provide an air passage under the inner sash a strip of wood is furnished with notches cut in for passageways and this can be screwed on to the bottom of the inner sash. In building new cars it is proposed that notches would be sawed into the sash itself but the strip is furnished in the event that the car owners would not wish to cut the old sash.



AIR INTAKE OPEN

The attractive feature of the whole appliance is that it can be attached to old or new cars as well by using only a few small screws, and without mutilating any of the present woodwork or interfering in any way with its present operation.

General News and Personal Mention

H. G. THOMPSON

Mr. Thompson's many friends in carlighting work will be pleased to learn of his recent election to the position of Vice President of the Edison Storage Battery Co.

There probably is not a better and more favorably known man in the whole carlighting game than "Harry" Thompson.

H. G. Thompson

He entered the employ of the Pullman Company in 1896 at the age of 21 and two years later was made foreman of electricians. In 1900 he resigned from this position to accept that of foreman of the battery department of the Riker Motor Vehicle Company. When this company was absorbed by the Electric Vehicle Company of Hartford the Elizabeth factory was abandoned and Mr. Thompson, not caring to move to Hartford, became associated with Mr. W. L. Bliss during his early development work and installed most of their equipment until such time as the Bliss Company was taken over by the Cutler Hammer Company of Milwaukee.

He resigned from the Bliss Company in 1905 and entered the employ of the Pennsylvania Railroad Company in charge of electric car lighting at Jersey City. In 1906 he became associated with the Safety Car Heating & Lighting Company, as electrical superintendent in charge of their electrical laboratory during the development of their present axle lighting equipment.

In September 1909 he became manager of the railway department of theWestinghouse Storage Battery Co., but this company was dissolved about three months later on account of the complete destruction of their plant by fire. He then became connected with a New York office of the U. S. Light and Heating Co.

In June 1910, however, when the Edison Storage Battery Co. first became active in the steam railroad field, Mr. Thompson was given charge of this department, and has since held the title of manager of the railroad department until his recent election to Vice Presidency.

W. E. BALLANTINE

The Willard Storage Battery Co., have announced the appointment, effective Sept. 1st, of Mr. W. E. Ballantine, formerly manager of their Chicago office, as Manager of Railway Sales with headquarters at Cleveland.

Mr. Ballantine, although possibly not classed as one of the "pioneers'" in the carlighting game has had a wide experience in this line which qualifies him particularly well for his new position. From 1900 to

W. E. Ballantine

1909 Mr. Ballantine was actively engaged in carlighting work with the Pullman Co. as electrical engineer and with the Rock Island chief electrician. In this latter position he did much excellent work in the tabulating of costs and establishing a comprehensive system of carlighting records. Mr. Ballantine was born in 1874 in Boonefield Mo., and at the age of twelve began his railway career as messenger boy with the old Kansas City, Fort Scott and Memphis Railway. From this humble start he has worked his way all down the line to the position of manager of railroad sales for the Willard Co. and his many friends in the carlighting field wish him the biggest measure of success in his new work.

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They are Different. LOOK FOR →

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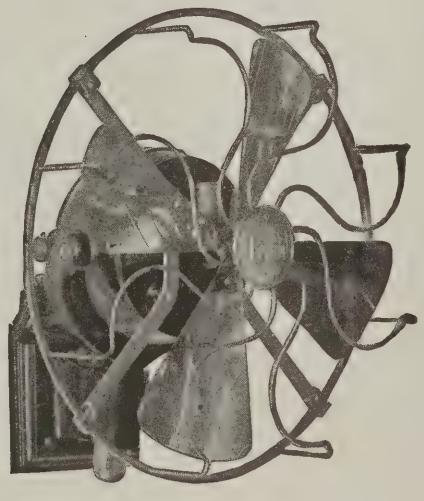

Diehl Car Fans
FOR
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They are the best. When the manufacturers could no longer improve the motor they improved the base. These bases are of artistic design and may be permanently mounted in the cars. The Fan is easily and quickly removed without disturbing its base. No marring of woodwork—no loss of time.

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Manson Tapes

For Insulating and Protecting Joints

OKONITE TAPE is a rubber insulated tape. Joints properly made with Okonite Tape are impervious to moisture and are as strong or stronger electrically and mechanically than the insulated wire itself.

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Replaces Arc Lamps for Railway Shop and Yard Lighting

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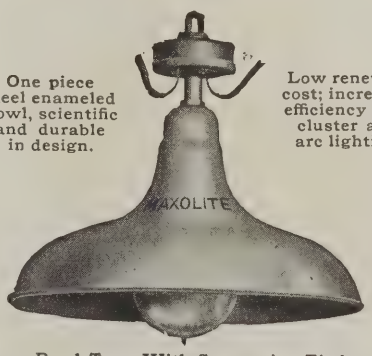
Low renewal cost; increased efficiency over cluster and arc lighting



Bowl Type With Suspension Fitting

and SERVICE—then write us. We are largest stock of electrical supplies East specialty. If you have *not* our big instruct- asking. Write for it on your letterhead.

rir Company

of Service CHICAGO, ILL.

C. A. LUCKEY.

Mr. C. A. Luckey has just been appointed sales engineer of the Edison Storage Battery Company, with headquarters at Chicago.

C. A. Luckey

Mr. Luckey is a graduate of the Franklin Military Academy '98, and Bliss Electrical School, Washington, D. C., '02, and has had considerable electrical experience, having been with the Western Electric Company two years, The Safety Car Heating and Lighting Company seven years and the Railway Utility one year, during which time he has made a wide acquaintance among car lighting men.

S.-K.-F. BALL BEARING RECORD.

The S. K. F. Ball Bearing Company report that a pair of their railway type No. 412 double row self-aligning ball bearings, fitted with 16 1 inch balls were removed for inspection from a car lighting generator on June 20th, 1913. These bearings had been in constant service for over nineten months on a car running between New York and Chicago during which time over 170,000 miles were covered. They were found to be in such excellent condition that they have again been put back in service in the same generator. Considering the saving to be effected in the amount of lubrication used, the saving in attention, the prevention of the danger of dropping armatures, as a result of worn bearings of plain type, and the constant expense, it has been demonstrated that the railroads can well afford to discard the old type bearings and specify a ball bearing that not only fills every requirement but will at the same time minimize up-keep costs and lessen repair costs.

The leading American Railroads are today equiping parlor cars, sleepers, coaches, diners, mail and baggage cars with electric lighting systems.

As has been found in the automobile, electric motor, machine tool, textile and woodworking machinery, and many other classes of machinery requiring capable bearing service, ball bearings provide an admirable solution of the costly and annoying troubles oftentimes caused by plain bearings. Anti-friction bearings have, it seems, come to stay.

POWERFUL OBSERVATION SEARCHLIGHT ON C. M. & ST. P.

The Chicago, Milwaukee & St. Paul R. R. have just established an innovation in regular passenger service which, if generally adopted, will do much to increase the interest and pleasure of night travel. A powerful 13 inch searchlight is mounted on the rear observation platform of one of the trains running between Chicago and St. Paul. For a considerable distance the road parallels the Mississippi River so there is much beautiful scenery made visible by the use of the searchlight which would ordinarily be lost to the night traveler.

The searchlight employs an arc of 20 amperes at 64 volts and delivers approximately 2,000 m. h. s. candlepower. The lamp lights up the surrounding country for a thousand feet or more so that any particular object of interest within this range can easily be observed. On the first trip the searchlight was used, July 16th, it aroused considerable excitement among the farmers whose houses were occasionally illuminated as the train passed by.

NEW NORMA BULLETINS ON BEARINGS.

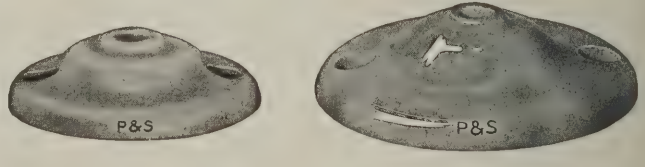
A set of three new bulletins has just been issued by the Norma Company of America showing the Norma line of roller and ball bearings. They are neatly illustrated with sectional and exploded views showing all the details of construction.

Each of the types of ball-bearings, roller-bearings, and thrust-bearings together with the various combinations of each have been listed in all their sizes. The load capacity in pounds at different speeds, and all dimensions for making up complete specifications are carefully tabulated.

A departure from American practice is noted in this company's use of the Metric System. All its bearings are made in sizes which are multiples of five millimeters. The equivalent decimals of an inch are given in parallel columns of their tables.

NEW PASS & SEYMOUR SPECIALTIES.

A new fuseless rosette was brought out in July by Pass & Seymour. It is made exclusively for use on outlet boxes and may properly be called an outlet box cover. Two sizes are offered The No. P. & S. 1172



for any of the 3 in. or 3¼ in. boxes and the No. P. & S. 1173 for any of the 4 in. boxes. They are put up in individual pasteboard boxes with the requisite number of screws for attaching in each.

THE AMERICAN PULLEY COMPANY CHANGES LOCATION OF NEW YORK STORE.

The American Pulley Company has moved its New York branch from 203 Lafayette Street into more commodious quarters at the corner of Grande and Greene Streets.

At the new address is carried a complete stock of "American" belt pulleys. Orders will be received for reels, spools, beams, sash pulleys and pressed steel shapes.

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of the Association of Railway Electrical Engineers.
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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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The October Convention.

Present indications are that the Sixth Annual Convention of the Association of Railway Electrical Engineers, October 20-24, Hotel La Salle, Chicago, is going to be bigger and better than ever before. The amount of space sold already far exceeds that of last year, and the present outlook is that all the space in both of the large exhibit halls on the nineteenth floor of the Hotel La Salle will be taken early.

The Committees of the Association have worked faithfully within the last year, and some valuable reports will be presented in addition to some very interesting papers on special subjects. The various committees on arrangements for the Convention have been active and are planning to provide some special entertainment features.

Standardization of Railroad Head Lights

During the past few years much legislation has been enacted regarding the use of high power headlights on locomotives. Some of the specifications as drawn up are meaningless when carefully analyzed, and some are foolishly absurd. None of the legislation is based upon any thorough knowledge of the subject, nor have any tests of a fundamental and comprehensive nature ever been made.

Several semi official tests have been made by various committees and commissions such as that conducted by the Wisconsin Railroad Commission, described in the Railway Electrical Engineer of November, 1912, and those made by Dean Benjamin of Purdue University at the request of the Indiana State legislature in 1910. These tests, however, were conducted for the most part by men who have had little or no practical experience with high power headlights as locomotive engineers, and the findings of each of these two commissions indicated so many false signals apparently caused by the headlights, that if the same percentage of error was experienced by the locomotive engineers driving the locomotives on certain roads which operate electric headlights extensively, the number of wrecks due to this cause would be very great. The fact that the opposite situation exists would indicate that there is some discrepancy of a serious nature between the methods of test and practical operation of this equipment.

There is such a wide diversity between the requirements in various states that railroads are largely at a loss to know what kind of headlight equipment to install in order to meet the many-sided specifications of the various states. A headlight which may be required in one state will not be permitted in another. The matter has now gone so far that it is of utmost importance that something be done to standardize this equipment, and to establish a suitable specification for headlight equipment which will be founded upon engineering facts and practical railroad experience rather than upon the whims of any legislative body.

The illumination committee of the Association of Railway Electrical Engineers has, during the past year, conducted a very thorough investigation of the subject of postal car illumination which has resulted in some very valuable data on this subject, a reasonable specification by the postal department and a standardization of lighting fixtures and layouts of lighting systems which will result in better service for the postal department and greater economy to the railroads. A similar series of tests are now being conducted by this Association on the subject of coach lighting and the results of this investigation will, without doubt, be even more complete and more valuable than the above.

It is of utmost importance to both railroads and the public that a similar investigation and standardization be made of locomotive headlights, and the illumination committee of the Association of Railway Electrical Engineers is without doubt in a better position to conduct such a series of tests than any other organization in the country.

The English Railophone

The accompanying illustration shows the Railophone wireless inductive system of railway telephony, telegraphy and signalling as developed at Birmingham, England. There are now well understood principles of electrical intercommunication by means of metallic cable circuits between two fixed stations, and by means of etheral waves between two moving objects such as ships at sea.

Both of these systems, owing to the highly efficient instruments invented during the last thirty years by Prof. David Edward Hughes, Dr. Alex. Graham Bell, Sir William H. Preece, Sir Oliver Lodge, Signor Guglielmo Marconi and many other scientists have reached that perfection necessary for a successful and practical application.

Until recently, however, neither of these principles nor

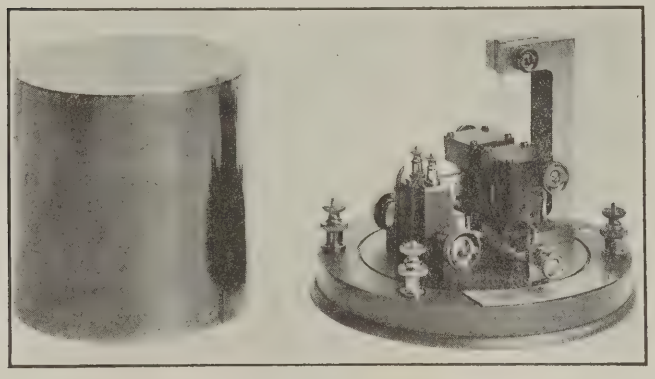


Fig. 1. Railophone Detector.

the existing instruments have been applied with any degree of success for the establishment of reliable intercommunication under modern conditions between railway trains in motion, or trains and stations, for which purpose an arbitrary code of primitive mechanical signals is still employed, augmented here and there by standard electrical apparatus adopted from recent developments in other branches of electrical engineering.

It is suggested that perhaps the conservative attitude and the unique experience of the railway engineer are largely responsible for this reluctant adoption of electrical methods of signalling on modern railway work, but surely the isolation of a traveling train deserves serious consideration with a view to placing it in tangible communication throughout the whole of its journey with the outside world and those responsible for its control.

On account of the many accidents which have occurred during the past decade it is urged that not only is this necessary for the benefit of the traveling public, but for the paramount safety of the passengers, in these times of even increasing speed of transport and daily growth of traffic.

In an experimental installation, Mr. H. von Kramer, an electrical engineer of Witton, near Birmingham, succeeded in establishing a telephonic link between an express train and a signalling box at Three Bridge Station on the London Brighton and South Coast Railway. He employed the principle of electric induction between apparatus carried on board the train and a copper cable embedded in the earth several feet away, parallel with but outside of the permanent way.

The first public installation of von Kramer called "railophone" at Stratford-on-Avon, on the Stratford upon Avon and Midland Junction railway and he then also announced the possibility of using the Railophone system, in addition to the transmission of telephonic or telegraphic messages for sending signals to and from trains and stations with the object of controlling trains and safeguarding them against collisions.

It will be seen that this prediction has since been realized, and the various applications of wireless inductive control are of special interest. The railophone is used as a train telephone. The equipment for the establishment of telephonic communication between a moving train and a station consists of a telephone transmitter and a pair of receivers, in the form of an operator's headgear, fixed in a sound-proof telephone box carried in the baggage car.

These instruments are electrically connected with two large insulated copper coils mounted in a wooden casing, called "the railophone frames," suspended by iron brackets from the coach. The "upper frame" is suitably wound for sending, and the "lower frame" for receiving a telephonic message.

The telephonic currents produced by the voice of the operator create a magnetic field which waxes and wanes in unison with the alternations of the voice. This field, emanating from the railophone "upper frame" induces an electric current of corresponding periodic pulsations in the metallic conductor buried in the earth alongside the railway track.

It is stated that this "ground wire" is connected to similar telephone instruments fixed at stations, and if desired may be linked up with the general telephone and telegraph system of the country. Telephonic conversation is carried on through the railophone just as through any ordinary telephone, no change-over switch from "sending" to "receiving" being required.

There is no mechanical contact between the "ground wire" and the moving train; the connection is "wireless" or accurately described as "wireless inductive," the telephonic current being transmitted through the space which exists between the ground wire and the lower frame on the passing train. Inversely, telephonic currents inductively imposed upon the ground wire by the upper train frame are picked up at the stations by telephonic receivers which are pressed by a steel band against the ears of the operator.

It is said that in the original railophone system there were no means of "calling up" and as is still the case with radio telegraphy on board ship, the railophone operators had to be in constant attendance. But that this shortcoming has recently been rectified by the introduction of a highly sensitive detector—the joint invention of Mr. H. von Kramer and Dr. Gisbert Kapp, professor of electrical engineering in the University of Birmingham. By the aid of the detector, which corresponds to a "coherer" in wireless—the exceedingly feeble electrical impulse received on the train from a vibrating charge sent into the ground wire are picked up and "relayed" into sufficiently strong currents to ring a calling bell, or sound a powerful hooter.

Now the ringing up of a station from a moving train is effected by the same means. The train telephone enables the conductor and signalman to communicate with each other—whether the train is in motion or at a standstill. For the purpose of traffic regulation, in case of accidents or during fogs or snow storms, business messages and messages to and from passengers can be "railophoned" with the same ease and accuracy as in ordinary telephone service.

The railophone is also used as a train telegraph. With slight modifications to the system as applied for telephony, and by the addition of a few telegraphic instru-

ments, the railophone can transmit telegraphic signals by means of a Morse key. It is said that on the Stratford upon Avon and Midland Junction Railway, either mode of communication, telephone or telegraph is employed without necessitating the use of change-over switches. But with this system of combined telephony and telegraphy, the sending operator can be instantaneously interrupted, a rather important feature in railway work in cases of emergency.

Again it is held that the railophone may be used for railway signalling the "Kramer-Kapp" resonating relay, mentioned previously and hereafter called the "K K" detector—is principally used for the detection of the railophonic impulses sent out from signal boxes or trains and is the key to the solution of the problem of automatic train signalling.

It is maintained that it is now possible to cause the ringing of bells, the sounding of steam whistles or motor hooters, the bringing into play of mechanical movements capable of opening or closing levers controlling steam valves of locomotives, signal levers interlocking gear, the operation of vacuum brakes or the ignition of indicating electric lamps—all for the purpose of direct or indirect control of trains.

This detector has even been successfully adapted for automatically stopping a train without the intervention of the guard or driver. The von Kramer system for automatic railophone signalling provides for the automatic blocking of a section against a following train and the liberation of the section after the first train has passed out of the danger zone.

It is also applicable to double automatic railway signalling. With the railophone it is now possible to not only signal from a train when it reaches the entrance of a section to the signalman, but also to signal from the signal box to the train irrespective of the position of the train in the section and whether the train is proceeding at full speed or standing still anywhere on the track.

The electrical equipment at the station consists of a signal box fitted with a "KK" detector, several sending, receiving and recording apparatus, and the necessary underground electric lines. These circuits are divided into three distinct groups viz:—the main section (of any suitable length from 1 mile up to 10 miles and more if desired) the restoring section, and the clearing section, the latter two sections being each approximately 100 yards long.

On the trains the electric equipment consists of two "railophone frames" fixed to an ordinary coach, and a series of apparatus for receiving, sending and recording signals. By means of the apparatus provided on the train and in the signal box a certain cycle of operation is carried out. At first when a train enters the main section a red lamp is lit in the signal box. The lamp is placed over that particular signal which controls the semaphore signal protecting this section. Then the red lamp continues alight as long as the train occupies the main section and until it leaves the restoring section.

Simultaneously with the light of the red lamp, an audible signal in the form of a bell or buzzer sound in the signal box. These visual and audible signals indicate to the signalman the entry of the train into the main section, and warn him of the necessity of protecting it by moving the signal lever into the "danger" position.

Then, unless the signalman responds to these signals with a fixed period of approximately 10 seconds, the signal lever is automatically pulled into the "danger" position. This automatic operation is simultaneously registered by a recording instrument.

Whether the signal lever has been pulled into the "danger" position by the signalman or by automatic means, it remains electrically locked in that position until the train has left the section. This renders any circumstances to again open the section to admit a second train whilst it is occupied by the first train.

In case the signal lever is automatically replaced, the train is allowed to travel the section, but apparatus are brought into play causing a powerful alarm gong to sound outside the signal box, and the incident to be automatically registered on a recording instrument, which indicated the time of the occurrence. By these means a severe control is kept over the signalman's actions.

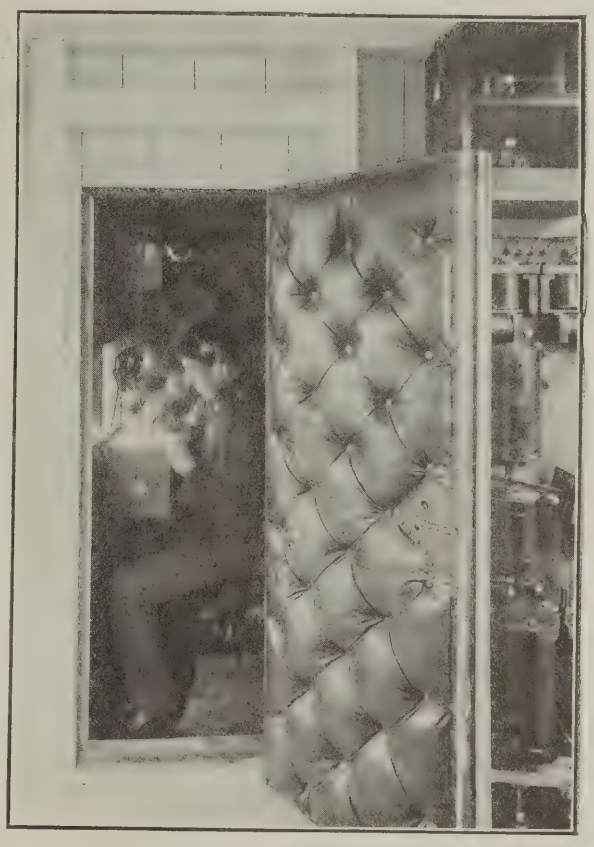


Fig. 2. Railophone Installation in Baggage Car.

Should the signalman operate the signal lever on being warned, nothing further transpires in the signal box until the train enters the clearing section, when the red lamp is automatically extinguished and a green lamp is lit, which is in turn extinguished when the train finally leaves the clearing section, the signal lever being simultaneously unlocked.

After the train has sent out the signals indicating its entry into the main section, it is, by means of a time limit device, enabled to receive signals or instructions affecting its movements while in the main section. In this receiving condition, the train can at any moment receive either telephonic or telegraphic instructions, and can be brought to a standstill by the signalman at will, or the guard on the train can if desired, place himself into communication with the signal box.

Under normal conditions a second train unless it overruns the danger signal at the entrance of the main section, can not enter the main section if same is still occupied by the first train. In the event, however, of the second train ignoring the danger signal, and entering the section, both trains are automatically brought to a standstill. This incident is also recorded on the train and in the signal box.

If a second train enter the section in the opposite direction to the first train, both are stopped, thus avoid-

ing all possibility of "head on" collisions. The train on entering the restoring section automatically receives, while passing through this section, an impulse which through the "KK" detector, brings into operation apparatus which first advises the signalman of the train's entry into the clearing section by automatically lighting a green lamp in the signal box and secondly, on entering the subsequent main section, indicates its approach to the succeeding signal box reproducing once more the cycle of signals as described.

As soon as the train has left the clearing section the instruments in the signal box are restored to their normal condition ready to deal with further incoming trains. If the train be prevented from entering the succeeding main section, the green lamp continues to glow, and in addition, the alarm gong is sounded outside the signal box the incident being again recorded.

It is said that simultaneously the main section is under current providing a double safeguard against the entry of a second train into the section. On receiving permission to enter the succeeding main section, the train may proceed. If the driver should proceed before he receives such permission the train is automatically stopped on entering the succeeding section.

In foggy weather the same system for signalling is applied and by the addition of a special fog signalling attachment on the train, the train is automatically stopped in each clearing section. By this means it cannot enter the succeeding main section unless such section is given "clear" by both signalmen. This is signalled to the driver by the sounding of a powerful hooter on the train and it is prevented from traveling over the succeeding main section until the driver has received the permission signal.

The transmission of signals is effected by induction via metallic circuits, which are laid underground and therefore impervious to accidental injury. There is a definite and continuous connecting link between signal boxes and trains thereby established throughout the whole of the train's journey.

These railophone signals are "uni-directional" and cannot stray to other trains as was the case when attempts were made to use the radio-telegraphic principle.

The five principal devices used in this signalling system include the stationary underground metallic circuit which is noninductive to outside influences and the movable circuit consisting of two large frames fixed to one of the coaches of a train, these frames serving for telephonic, telegraphic and signalling communication. There is also the turnable detector acting as a sensitive relay under railway conditions and the alternating current apparatus and instruments for sending signals. Finally there are the automatic solenoids operating the alarm signals and controlling gear.

It is said that the adoption of a railophone automatic signaling plant does not entail any modification of the existing rules and regulations, with the exception of the audible and visible signal in the signal box there are—under ordinary working conditions—no additional apparatus to be attended to by the signalman.

As the engine does not carry any railophone apparatus whatever, the driver is not diverted from his usual duties, all the railophone appliances needed to control and protect a train are mounted in the baggage car, and the engines are in no way interfered with and can be coupled to or uncoupled from trains in the ordinary way. Any inattention or carelessness on the part of the locomotive engineer would be carefully and automatically recorded and could be consequently used as evidence against them.

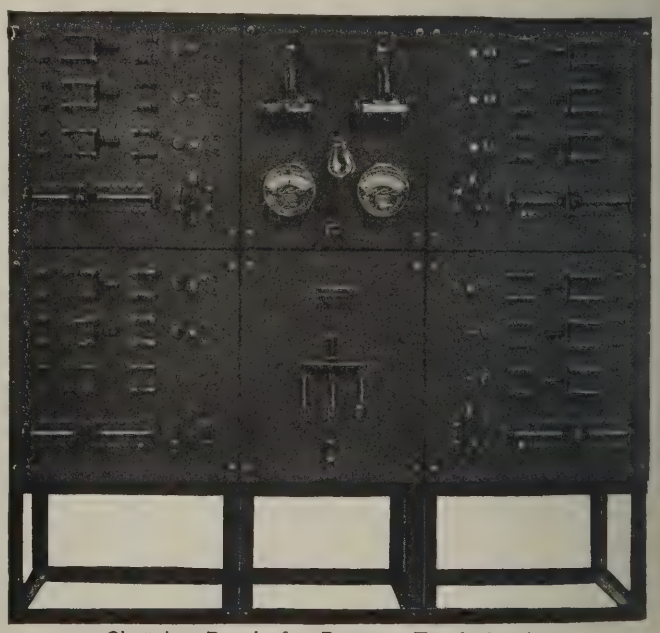
It is evident that by thus constantly checking every irregularity, it is considered that the large number of daily occurring minor accidents—which are frequently more serious—will be greatly reduced if not wholly avoided. While all mistakes are duly recorded, the system provides substantial means for automatically retrieving such errors and so prevents collisions.

The British Railway regulations require that in the event of a train being brought to a standstill, the engine driver or fireman must proceed to the nearest signal to obtain instructions; this may be amended, as by means of the railophone the driver or guard is enabled to speak from the train to the signalman, no matter at what point the train has been pulled up.

BATTERY CHARGING PANELS.

For the charging of the batteries of motor-driven baggage trucks, the Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., has manufactured and installed a number of charging equipments, one of which is shown in the accompanying illustration. This is installed in the North Station of the American Express Company and is designed to charge from one to twelve of the twelve- cell trucks at one time. There are four charging-rheostat panels, two on each side of the center panel, and each of these is arranged for charging one truck alone, or two or three in series. The rheostats are of the slider type with resistance grids mounted in frames back of the panels. The double-throw switches, above the rheostat contacts, when thrown to the right connect the batteries of the two or three trucks in series, and when thrown to the left cut into the circuit a fixed block of resistance sufficient to absorb the line voltage above that of the battery at maximum current.

The arrangement for charging in groups allows the most economical use of current while at the same



Charging Panels for Baggage Truck Service.

time keeping the number of separate rheostats to a minimum and the price consistently low. One truck can be charged alone if necessary, but it is usually possible to put two or three on charge at the same time.

The center panel carries two meters, the main switch and single-pole circuit-breakers for each of the outside wires of the three-wire system on which this equipment is installed. In this particular case plug receptacles were placed on the panels with tell-tale lamps.

The Kohlererberg Aerial Railway Line

By FRANK C. PERKINS

The electrically operated aerial railway up the Kohlererberg near Bozen and its equipment may be noted in the accompanying photographs. This installation shows one of the best solutions of the problem of transporting goods and passengers up heavy inclines such as a mountain side or irregular formation.

The illustrations of this Aleichert electric aerial railway give a good idea of the tremendous grades which are encountered. It will be observed that the cars are suspended from cables and are as comfortable as a modern electric car, and travel in a smooth and easy manner along steel suspension cables.

The Kohlererberg aerial line has a total length of 1,650 meters carried by 12 structural steel supports of form shown in the photograph, the highest of which is

Fig. 1. Kohlererberg Aerial Railway Line.

about 27 meters or about 90 feet above the ground, and a distance of 430 meters from the lower station.

The passenger cars are each capable of holding 15 passengers and the driver, and two cars travel simultaneously each way at one time. The speed is 3 meters per second and such that in thirteen minutes a difference of level of 840 meters is traveled each car being pulled by two traction cables which are operated from a power station placed close to the line.

It may be stated that the object of duplicating the cables is to secure safety in case of the breakdown of one of the cables, and the same means is adopted in connection with the suspension cables.

The cars are supported from a traveling mechanism carried by eight pulleys. Each of the steel cables on which those pulleys travel are 44 millimeters in diameter. It will be seen that the cars can swing like a pendulum while a brake retards undue oscillation. All fear of derailment due to oscillation sideways is avoided by the fact that the carrying cables themselves swing with the car.

The drive is by electric motors and in order to secure

Fig. 2.. Aerial Car with Suspension Cables & Tower.

immunity from breakdown of the transmission system even if the power plant fails to operate a storage battery is installed which operates in parallel with the generator.

To provide communication, a system of telephones and electric signals is installed throughout the track, and the driver from any part of the line can communicate with either the upper or lower terminal station.

It is said that the cars cannot be started before the necessary signals have been given between the two stations and confirmed so that there is no danger of mistake. In addition to this, safety is most efficiently studied in connection with every detail of the equipment.

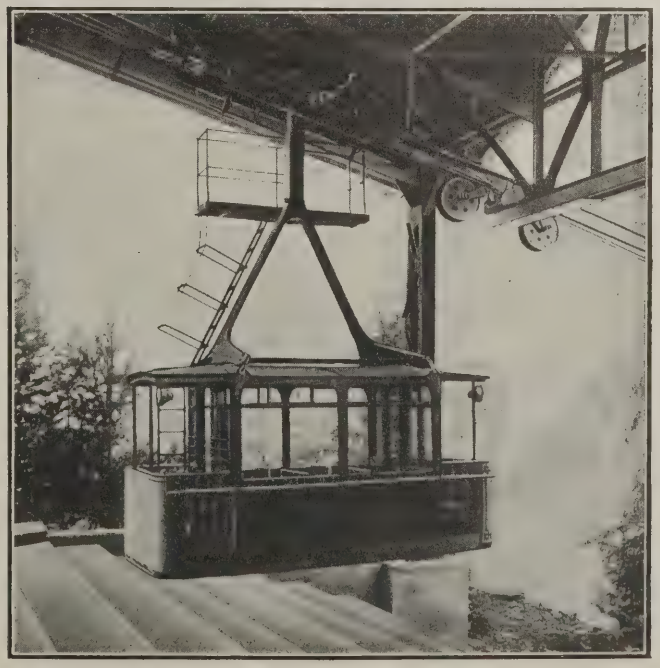


Fig. 3. Aerial Car in a Station.

Fig. 4. Aerial Line Tower and Cables.

It is pointed out that the traveling mechanism of the car contains two braking arrangements which operate automatically if there is an excess of speed. The same device operates if the carrying cable breaks or if a break should occur on either one or both of the hauling cables. Besides being automatic the operator can put the brakes into service by hand, the operation being simple and quick, and when this catching device is put into action steel jaws grip the carrying cables at eight different places. The friction is sufficient to hold the car firmly in position even on an incline and simultaneously, by the movement of the same mechanism, the supply of electricity to the driving motor is stopped and the brake is instantly applied.

To provide further security and insure the safety of the passengers in the event of a breakdown there is a spare car kept at each station in readiness to go to the point where the ordinary car is left suspended, transferring the passengers and bringing them back to the nearest available station.

Fig. 6. Truck for Aerial Car.

It is said that the regular passenger car is also fitted with a special device in the floor by means of which it is possible to lower the passengers to the ground from the car direct. This hoist is fitted with a brake to prevent undue speed of the descent and should the driving gear of the whole line break down, thus stranding the cars in the middle of the route, an auxiliary winder is available for bringing the cars back to their terminal position.

Fig. 6. Guide Pulleys for Cable on Tower Arms.

It is claimed that this application of the electric traction has been so carefully designed in all its details that absolute safety and reliability of service is assured. In this aerial system of transmission a great number of difficulties have been avoided which would otherwise have been encountered in proceeding over such a rough and mountainous section of route and the service has been most successful since the line was opened. The towers which support the cables vary in height from 7 meters, or about 25 feet, to 27 meters or 90 feet in height.

AMERICAN PULLEY CO. ADDS NEW BUILDING TO PLANT.

The American Pulley Company, of Philadelphia, makers of steel split pulleys, have increased their equipment with another big building. This new building contains 54,000 sq. ft. of floor space, or about 1¼ acres. It will easily store 40,000 belt pulleys, but will also be devoted to the storage of sash pulleys, bushings and all finished products.

The entire structure is absolutely fireproof. It has brick walls, tile roof, concrete floors, metal racks, metal bins and shelving, and metal window frames. There is more floor space under this one roof than was occupied by the entire plant when established here 13 years ago. There will be a second story office 80 ft. by 100 ft. The office staff will move into its new quarters in October.

While "American" pulleys have always been quickly obtainable, due to the well-stocked branch houses of the company in Boston, New York and Chicago, and from over a thousand dealers advantageously located throughout the country, this big new storeroom will now make possible larger stocks being carried in Philadelphia of every size of pulley, from 3 in. to 60 in. diameters. Shipments to any point, domestic or foreign, will be greatly facilitated and more efficient service can be rendered to customers.

New Type of Electric Locomotive for Norfork & Western Electrification

The Norfolk & Western Railroad, which extends from the Tidewater at Norfolk, Va., to the coal fields of West Virginia, has contracted with the Westinghouse Electric & Manufacturing Company to supply all the electrical apparatus required to electrify the Bluefield-Vivian section of its line, some 85 miles in length.

The carrying out of this contract will give form to one of the most important projects of steam railroad electrification yet undertaken. The contract calls for the manufacture and delivery of twenty-six 130-ton electric locomotives of the single phase-two phase type, together with all required power house generating machinery and transmission apparatus.

The Bluefield-Vivian section serves the celebrated Pocahontas coal region, one of the largest coal fields in the world. The tonnage of coal handled amounts to 65,000 tons per day, necessitating trains weighing as high as 3,250 tons. It is to facilitate the handling of this heavy traffic that the electrical operation has been decided upon.

There are a number of grades on this section, the maximum being two per cent, and at the present three Mallet locomotives (the most powerful type of steam locomotives built) are required per train. One locomotive is used at the head of the train and two for pushing.

Only two electric locomotives will be required for this service and the present speed will be doubled. The extent to which this quick train movement will enlarge the capacity of the railroad is quite apparent.

Since the locomotives are intended for handling what is known as "tonnage trains," they will be built for running speeds of approximately seven, fourteen and twenty-six miles per hour.

Power for the entire electrified section will be generated in a central power house located at Bluestone, W. Va., with an installed capacity of 27,000 kilowatts in turbo generators.

The motor design of these locomotives embodies many interesting features, which are radical departures from past practice. Although the energy is generated and transmitted as single phase current, the design of motor control is such that the motors operate at slow speed and starting essentially as polyphase motors. They are designed for three operating speeds of 7, 14 and 28 m. p. h. A so-called "phase-splitting" device, which is in reality a rotating phase converter, will be used to produce the quadrature current relation necessary for polyphase excitation during normal operation as well as at starting.

Each locomotive will carry four polyphase induction motors, having a total continuous rating of 1,300 h. p. at 14 m. p. h. Each motor will be controlled through rheostats connected in their secondary circuits. The primary windings of the motors are so designed as to produce 4 or 8 poles, as desired. In starting with the 7-mile combination the motors on each truck will be connected in series and the two sets will be connected in parallel. Resistance will be inserted in the secondaries at starting. In this combination the primaries will be arranged for eight poles. With the 14-mile combination all motors will be in parallel connected for eight poles, and with the 28-mile combination the four-pole arrangement will be used, resistance being used on intermediate steps.

The induction motor has been selected for this service, because of important considerations of cost and space and also because the operating conditions of this division, involving heavy grades, the three-speed polyphase operation provides excellent regenerative control. This latter feature is important, not so much from a consideration of saving in energy as from the safety in descending a grade. There is, incidentally, a saving of brake shoes and ties. When other trains are being operated in the electric division, the regenerated current of the locomotive running down grade, will be utilized; when there are no ascending locomotives, the regenerated current will be absorbed in suitable rheostats at the power plant.

The polyphase voltages applied to the primary circuits of the driving motors must receive approximately balanced voltages. For this purpose there will be installed in the cab of the locomotive a rotating "phase splitter" or phase converter which will receive exciting and driving energy from the secondary of the single-phase step-down transformer in the cab and deliver current in time-quadrature phase relation in order to supply magnetism in time-quadrature to the direct supply single-phase magnetism in the propelling induction motors. The latter motors will therefore start from rest as polyphase induction motors. Being arranged for eight poles and connected in cascade, they will operate initially as though they were sixteen-pole machines and accelerate toward a corresponding synchronous speed, above which they will operate as induction generators to return energy to the supply system. When connected in parallel and arranged for eight poles the motors will reach a synchronous speed at twice the linear speed corresponding to cascade connection, and will return energy to the system when driven above this speed. A higher synchronous speed is again found at double the latter linear speed when the motors are arranged for four poles.

The traffic conditions of this section of the road are especially well adapted to electrical operation. It is in reality a separate engine division at present, and can be operated electrically without affecting the cost of engine service on other sections of the line.

Conditions that are conducive to high economy in an electrification like that of the Norfolk & Western are:

1. Traffic requirements such that a minimum electrical equipment will give practically continuous service.
2. Fewer engine crews per train.
3. The speed of operation over the division will be nearly double that possible with present steam equipment.
4. Increased capacity of electrified section.
5. Electric locomotives are not limited to the short hours of service on account of boiler and fire conditions as in steam locomotives.
6. Watering and coaling delays incident to steam operation will be entirely eliminated.
7. The general reliability of locomotive operation will be considerably improved.

Work will be begun at once, and the contract calls for its completion in the summer of 1914.

Some Calculations Involved in Electric Traction

(Continued from August)

The weight on drivers is

$$108—30=78 \text{ tons}$$

As now modified, we may take the complete weight of the electric locomotive as 108 tons, of which 78 tons is on drivers. For the electric equivalent of our typical steam train we thus have a train with a total weight of

$$108 + 750 = 858 \text{ tons}$$

as compared with the weight of

$$185 + 750 = 935 \text{ tons}$$

for the steam train.

For the electrically propelled train the average tractive effort for the journey is

$$9 \times 108 + 9 \times 750 = 972 + 6750 = 7722 \text{ lb.}$$

The average power required at the rims of the drivers works out at

$$\frac{50 \times 5280 \times 7722}{60 \times 33{,}000} = 1030 \text{ h.p.}$$

The energy expended at the rims of the drivers during the 100-mile journey is

$$2 \times 1030 = 2060 \text{ h.p-hr.}$$

The overall efficiency from the coal pile in the power house, to the rims of the drivers, is, for practically any well designed and commercially sound railway scheme purchasing its electricity from large, independent electricity-supply stations, of the order of 6.0 to 6.5 per cent.

For a service of trains making long runs between stops, a value of 6.5 per cent may be considered as representative of the order of magnitude of the annual overall efficiency from the coal pile in the generating station to the rims of the driven wheels on the train.

Then the quantity of coal (of a calorific value of 14,000 B.t.u. per pound, or 5.5 h.p-hr. per pound), burned at the electricity-supply station, which should be debited to the 100-mile journey of our express passenger train amounts to

$$\frac{2060}{5.5 \times 0.065} = 5750 \text{ lb.}$$

This constitutes only

$$\frac{5750 \times 100}{12{,}240} = 47 \text{ per cent}$$

of the amount of coal which is required in the case where the same train of 10 Pullman coaches is hauled by a steam locomotive.

The quantity of coal in the two cases may be compared as follows:

122 lb. per train-mile for steam locomotive

58 lb. per train-mile for electric locomotive

Including the locomotives in the weights of the trains, these figures reduce to

$$\frac{122}{935} = 0.130 \text{ lb. per ton-mile for the steam train}$$

and

$$\frac{58}{858} = 0.068 \text{ lb. per ton-mile for the electric train.}$$

Editor's note—With the latest type high speed electric locomotives being furnished the New York Central Lines, motors are mounted on the guiding trucks so that this element of "dead weight" is eliminated, yet all the advantages of the guiding trucks retained.

But on the basis of coal consumption per ton-mile of *useful* load (*i. e.*, per ton mile *behind the drawbar*) we have:

$$\text{For the steam train, } \frac{122}{750} = 0.163 \text{ lb. of coal per ton-mile}$$

$$\text{For the electric train, } \frac{58}{750} = 0.077 \text{ lb. of coal per ton-mile.}$$

To the railway the question of so designing its system as to secure the requisite conditions with a reasonable outlay for sub-stations and for the feeders and the contact-conductor system becomes one of much importance. For a relatively sparse service, the 2400-volt system bids fair to be adopted widely. We have seen that the average power required at the drivers of an electric locomotive hauling 10 Pullman coaches at an average speed of 50 miles per hour is some 1030 h.p. At constant speed, the efficiency of the electrical equipment on the train will be of the order of 90 per cent, The average input will thus be a matter of some 1150 h.p. But during acceleration and when ascending grades, the input will rise, say to, 1600 h.p. or $(1600 \times 0.746 =)$ 1200 kw. At 2400 volts this requires collecting a current of

$$\frac{1{,}200{,}000}{2400} = 500 \text{ amperes}$$

This current can be collected by pantograph trolleys.[3]

For 2400-volt sub-stations, the spacing will usually be from some 30 miles apart for a relatively sparse service of high-powered trains, down to some 15 miles apart with more frequent trains. With any approach to a dense service, 1500 volts or 1200 volts would amply suffice, the sub-station spacing ranging from 15 miles down to some five miles.

Returning to a consideration of the 2400-volt system, it may be said that pairs of 1200-volt motors in series will, so far as control-methods are concerned, take the place of single motors. The most usual plan will consist in driving four axles of the locomotive from the four motors. But 1200 volts is by no means the limiting pressure for the commutator of a railway motor and it would be sound engineering to employ four 1800-volt motors connected in 3600-volt pairs on a four-axle locomotive operated from a 3600-volt contact conductor.

Hypothetical Example.

Let us contrast a case of employing 10 electric locomotives weighing 160 tons each, and with the entire weight on drivers, with the alternative of employing 15 steam locomotives of the Mallet type, weighing, with tenders, 250 tons each, of which 160 tons is on drivers. Let the work to be performed consist in hauling freight. Let the conditions governing the capacity per steam locomotive consist in the requirement of hauling 1400-ton trains up long 1.5-per cent grades at 6.5 miles per hour, and starting 1400-ton trains on 1.5-per cent grades, and let it be proposed that the electric locomotives shall start and haul trains of the same weight over the same grades at speeds 50 per cent greater. Let the total length of single track including terminals and sidings, be a matter of 50 miles.

3. For a given life of the contact roller, tests reveal the following relation between the speed of a pantograph trolley and the current which can be collected:

Speed in miles per hour.	Current in amperes.
10	1200
20	900
30	600
40	450
60	300

When estimating on two pantograph trolleys in parallel, it is well to consider their combined capacity as only 1.75 times that of a single trolley.

EDITOR'S NOTE:

Through the courtesy of the officials of the Pennsylvania Railroad, we have been given special permission to publish this entire course in the *Railway Electrical Engineer*, so this valuable training in electricity, which was originally intended only for P. R. R. men, now becomes available to all railroad men. A complete lesson of this course will be published in each issue.

Lesson No. 4

Caustic Soda Cells.

The different types of these cells such as the Edison "R. R.", "BSCO", and Gordon depend upon the same principle for their operation, although they vary in capacities and in some of the details of construction.

Elements.

They consist of an oxide of copper plate, known as the positive terminal (+), and oxide of zinc plates, forming the negative terminal (—). These are immersed in a solution of caustic soda and water, which forms the electrolyte.

In the Edison cells, shown in Figs. 5 and 7, the zinc plates are rigidly fastened together on opposite sides of the copper plate, although the zinc plates are insulated from the copper plate. In the Gordon cell, shown in Fig. 6, the copper oxide plate shown in Fig. 8, is in flake form in a perforated cylinder, which is provided with three porcelain insulating supports or lugs, two of which are shown in Fig. 6. The zinc plate in circular form, shown in Fig. 9, forms the other element of the Gordon cell.

The positive connection is brought out at the binding post in the center of the cover, which also serves to suspend the plates.

The negative connection is made by means of the insulated wire at the side of the cover and which runs to the zinc plates.

The action of the cell gradually dissolves the zinc plates, and

Fig. 5. BSCO Cell with Soda and Battery Oil for Charge, Glass Jar Used to Show Plates.

converts the oxide of copper into pure copper by taking away its oxygen. The copper oxide at the surface is the first to be converted into metallic copper, the reduction gradually penetrating towards the center. When the cell is exhausted, nearly all of the black oxide of copper is reduced to metallic copper. The amount of unused oxide in the Edison cells can be ascertained at any time by picking into the plate with a penknife. The portion that has been exhausted, and converted into metallic copper will be red or copper color, while the unchanged oxide of copper will be black. This affords another way, though less convenient, of determining when the cell is exhausted, or about what proportion of its capacity is consumed.

However, for convenience and to avoid the possibility of injury to the cell, it is recommended that this be determined by an examination of the zinc plates.

To Determine When Cells are Exhausted.

Edison-BSCO Cells are equipped with zinc plates made from pure zinc, having ribs on their inner surfaces, as shown in Fig. 10, for the purpose of maintaining the entire surface of zinc until the rated capacity of the elements has been discharged. This makes it difficult to tell, by examination of the edges of the plates, how much has been consumed, but the zinc in the plates is so distributed that the lower panels will eat through, as shown in Figs. 11 and 12, when the rated capacity has been discharged.

When the zincs are consumed, the copper oxide plates will be reduced to metallic copper and will be brick red or copper color practically throughout their entire mass, as the amount of material in the plates is such that there will remain only a very thin layer of black oxide in the center when the cell is exhausted. The solution will also be exhausted, as it will then have become saturated with sodium zincate.

The active materials in each type of these cells are so proportioned that each element becomes exhausted at nearly the same time; therefore, when holes appear in the zinc plates, the cells will be practically exhausted and the entire charge, consisting of zinc, copper oxides, caustic soda and oil, should be renewed.

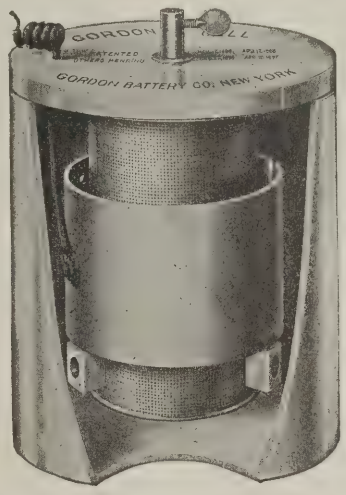


Fig. 6. Gordon Cell, Cut Away to Show Assembly of Parts.

In many of the signal installations, the renewals are made late in the fall so that the cells will be in good shape for cold weather regardless of whether or not they are entirely exhausted. The proper size of cell is used to avoid making renewals oftener than once a year, unless at some very busy point, and also to prevent wasting the elements by using too large cells. An occasional voltage test would readily detect any defective or exhausted cells.

To Set Up or Renew Cells.

Renewals for each type of cell consist of copper oxide and zinc plates assembled, one can caustic soda and one bottle of battery oil. This is just sufficient for one cell. The capacity

Fig. 7. Assembly of R. R. Cell, Side Cut Away to Show Assembly of Plates.

Fig. 8. Copper Oxide in Flake Form in Perforated Cylinder for Gordon Cell.

of the cell should always be mentioned when securing renewals.

Remove covers with exhausted plates attached and clean jars thoroughly. Before filling, tap jars to see if they are cracked. Cracked jars should not be used.

Fill the jars with pure water (rain or distilled water preferred) to 1¾ inches from the top. Disregard colored lines, if any, on inside of jars. Avoid hard water containing lime, iron, etc.

Caution.—Be careful, in emptying old solution and mixing the new, to avoid spilling it on either the clothing or skin. Should it get on the hands or face, wash off at once, or if water is not available, wipe off with a rag or soft paper.

Add gradually one can of soda to the water in the jar, stirring with a piece of wood until the soda is thoroughly dissolved. It is best to mix a little soda at a time; if the entire contents of a can are poured in at once some of the soda may solidify in the bottom of the jar. Be sure that all particles of

Fig. 9. Zinc Plate with Wire Attached. Gordon Cell.

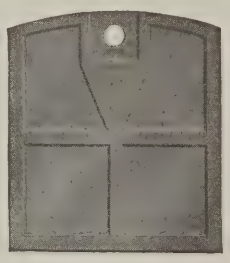


Fig. 10. View of New Zinc Plate BSCO Side Toward Copper Oxide Showing Ribs.

the soda are dissolved before proceeding further.

Detach exhausted plates from cover by removing nuts and washers from suspension bolt.

Attach new plates to cover after removing any packing material from between the plates which may adhere to them. The zinc plates should always be placed so that the hole or slot in cover is on the side of the zinc to which the wire is connected.

With covers having a hole near the edge, for the connecting wire, the wire should be straightened and threaded through the hole before passing the suspension bolt through the central hole in the cover. With covers having a slot in the edge, for the connecting wire, the elements should be attached by passing the suspension bolt through the central hole in the cover, and the wire placed in the slot after the zinc plate is fastened.

The solution, which becomes very hot while mixing the caustic soda, should be allowed to cool to about 90 degrees Fahrenheit before the plates are inserted in it. The elements should never be immersed in the solution while it is still hot.

Fasten the assembled plates securely to the cover by screwing down the lower nut on top of the cover, and place the cover, with the elements attached, in position in the jar. Move the cover a little to one side and pour in one bottle of oil, being careful not to raise the plates above the top of the electrolyte.

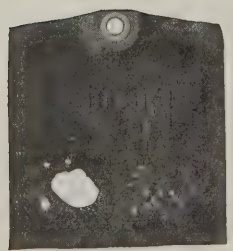


Fig. 11. Appearance of Zinc Plate when Completely Exhausted. BSCO.

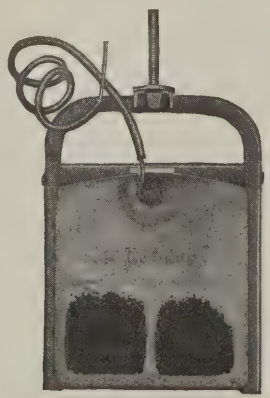


Fig. 12. Appearance of Zinc Plate when Nearly Exhausted, BSCO Cell.

It is important that the oil should not be omitted, and also that it should not be poured on the solution before the plates are inserted.

Assembly of Parts.

The only permanent parts to be retained when the cell is exhausted are the jar, cover, nuts and washers.

It requires the tightening of only one nut to fasten the plates in place, and only one connection per cell to connect a number of cells in series, as the connecting wire is permanently connected to zincs.

No parts that have been in the solution are used or handled in renewing; therefore, no handling, scraping or cleaning of such parts is required.

Fig. 13. Assembly of Copper Oide and Zinc Plates, BSCO, Showing Supporting Frame, Rod and Middle Positive Terminal, Connection of Wire to Zinc Plate or Negative Terminal.

The BSCO Cell.

The copper oxide and zinc plates are suspended in the solution by a channelled horse-shoe or inverted U-shaped frame, as shown in Figs. 13 and 14, hung by a threaded bolt which is permanently attached to the frame. The channels of the hanger embrace the flat and beveled side edges of the copper oxide plate, and the tongues at the bottom of each leg of the hanger are bent inward under the bottom corners of the plate. The channels of the hanger are drawn tightly against the edges of the oxide plate by a crossbar fastened in the frame just above the top of the oxide plate, thus making forcible contact with the plate.

The zinc plates are hung from porcelain insulators which pass through the crossbar, the zincs being held firmly in position by an amalgamated steel bolt. The copper oxide and zinc plates are properly spaced by the insulators, and the plates are fastened permanently in their best relation. Therefore, it is not possible for the zincs to be attached loosely to the cover or to touch the copper oxide plates, nor can they be spread too far apart, causing increased internal resistance.

Fig. 14. View of Edge of Plates, BSCO Attached to Cover.

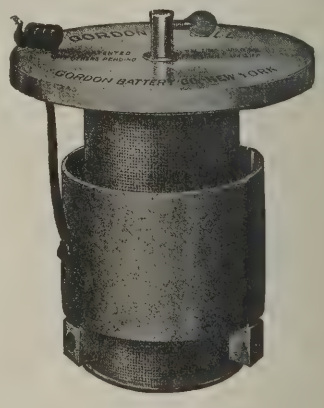


Fig. 15. Assembly of Plates and Cover. Gordon Cell.

The Gordon Cell.

The parts should be assembled as shown in Fig. 15. To do this, place the zinc on the lugs of the perforated cylinder, run the zinc wire through the hole in the cover and fasten the cylinder to the cover by screwing the brass connector, Fig. 20, into the nut at the top of the perforated cylinder.

See that no copper dust is on the porcelain lugs. The opening of the zinc plate, shown at the right of Fig. 9, should not rest upon the lugs, but should be placed between two of them.

When the elements are put into the solution, the zinc plate should rest evenly on the lugs, and care should be exercised to prevent splashing the solution on the hands or clothing.

Copper-Oxide Plates.

The Copper-Oxide Plates, shown in Figs. 8, 21 and 22, serve the double purpose of negative elements and depolarizers, the oxygen in the plates combining with hydrogen as the latter is set free in the action of the battery.

These plates are made of black oxide of copper. As this is,

Fig. 16. Renewal for BSCO Cell.

in itself, a very poor conductor, a film of metallic copper is produced on the surface of the plates and cylinder by a special process, to insure proper conductivity.

All copper-oxide plates have a bright copper or brick red color when they leave the factory, and will remain in this condition practically indefinitely if kept in their original wrappers and in a dry place. This surface film, like all copper, tends to oxidize or tarnish if it becomes wet or if exposed to damp air. It will also be affected if the plates are immersed in the caustic soda solution while it is hot or if the battery remains idle, or on open circuit for a considerable period immediately after the plates are inserted.

If the battery is discharged through resistance for an hour or more immediately after it is set up, the plates will acquire a permanent copper surface, and periods of open circuit, thereafter, will do no harm. If however, the plates have been wet or exposed to a moist atmosphere, they will have a dark color, and, in such case, it may be necessary to keep them on closed circuit (not short circuit), for a long period, to restore them to their normal condition.

This may be accomplished quickly by short circuiting for one or more periods of three minutes each, with intervals of rest of five minutes between each short circuit; but as far as pos-

Fig. 17. Renewal for R. R. Cell.

sible, short circuiting should be avoided, as it is likely to produce scale on the zinc if continued too long.

Zinc Plates.

The zinc plates are made from pure zinc and are amalgamated with mercury to prevent local action.

Caustic Soda.

The electrolyte or solution is made by dissolving one can per cell of the caustic soda (sodium hydroxide) in water as directed.

The Soda furnished with the cells and renewals is a special grade, ground and put up in sealed cans, each can containing the proper quantity for one cell. The label indicates the

Fig. 18. Porcelain Jar and Cover, Gordon Cell.

particular type of cell for which each can is intended, and care should be exercised to see that the proper can of soda is used in setting up or renewing cells.

A practice followed by some in renewing a large number of cells at one time, is to mix the caustic soda and water in a large tank, kettle or other receptacle and then fill the individual cells from this. With this method the solution is not all of the same density, that at the bottom being the stronger, which would not give uniform results in the different cells.

It is most important that the entire contents of one can, shown in Figs. 16 and 19, be used for each cell, and the solution stirred until all of the particles of soda are thoroughly dissolved.

The cans must not be opened until ready for use, as the soda rapidly absorbs moisture, causing it to cake. It also combines with the carbonic gas in the air, forming sodium carbonate, which, if excessive, will decrease both the efficiency and the capacity of the electrolyte.

When the soda is added to the water, the temperature of the solution rises rapidly. Breakage of jars, porcelain or glass, will be avoided if they are *not* placed on cold surfaces while mixing the solution.

Water.

The purest water gives the best results, though such water as is available at most locations will answer for all practical pur-

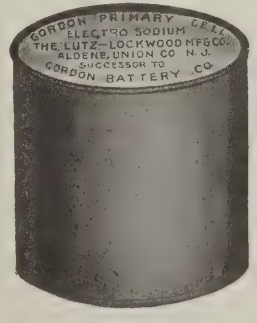


Fig. 19. Caustic Soda for Gordon Cell.

poses. Rain water that has been collected and kept in wooden receptacles or distilled water will give excellent results. Avoid "hard" water, containing lime, iron, etc.

It is most important that a sufficient amount of water be used to cover the plates properly and if an insufficient amount of water is used, it will increase the possibility of the solution freezing in cold weather. The plates must always be completely covered by the electrolyte. In cells properly set up, the top of the zinc plates will be at least an inch below the surface of the solution after the liquid has cooled.

Special Battery Oil.

The oil supplied with the cells and renewals, shown in Figs. 16, 17 and 23, is a heavy mineral variety, selected because it has no chemical action on the soda solution. The objects of the oil are three fold: it prevents evaporation, crystalization and creeping, and the carbonating of the solution by preventing contact with the air.

It is most important that the proper oil be used, as many oils form a soapy compound when combined with soda.

It is also important that the oil be poured in the jar after the plates are inserted; if dry plates are passed through the layer

of oil it will adhere to and soak into the copper oxide plates. If, however, through an oversight, the oil has been put on the solution before inserting the plates, the plates must be dipped in water, so that their entire surface is moistened. They will then pass into the solution without the oil adhering.

Selection of Cells.

These caustic soda cells are equally suitable for open circuit (intermittent discharge) or closed circuit (continuous discharge).

It is important, in order to obtain the best results, that the proper number of cells be used to furnish the necessary working voltage and that the type selected be large enough to deliver the current required.

Fig. 20. Brass Connector or Binding Post for Gordon Cell.

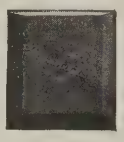


Fig. 21. Black Oxide of Copper Plate for R. R. Cell.

The open circuit or initial voltage of all these cells is .95 volt per cell; but in all batteries, either primary or secondary, the initial or open circuit voltage is higher than the effective or working voltage on continuous closed circuit. The high initial voltage is effective for work only when cells are discharged at an extremely low current rate, and in some cases, such as with ordinary "dry cells," even at low rates of discharge, it is available only for intermittent contacts of short duration.

The closed circuit or effective voltage depends, in all cases, upon the frequency and duration of contacts, internal resistance of the cell and the rate of current discharge, the voltage dropping proportionately as the rate of current flow is increased. With the 400 Ampere Hour BSCO types, for example, the mean effective voltage on continuous closed circuit, with current flowing at the rate of one-half ampere, is approximately .65 volt per cell; at one ampere .6 volt per cell; at two amperes .55 volt per cell; at three amperes .5 volt per cell, and so on. The Gordon Cell is nearly the same as above.

The rating of the standard caustic soda cells is as follows; 100, 150, 200, 250, 300, 400 and 600 ampere hours, but their voltage is all the same.

When the external circuit of the cell is completed, that is, when current is being drawn from the cell, the zinc dissolves in the caustic soda forming sodium zincate. The hydrogen gas which is set free by this process immediately attacks the copper oxide plate, reducing it to metallic copper and at the same time forming water from the oxygen and hydrogen. Sodium oxide, which is also formed, is unstable in water and unites with it to form caustic soda, which is the same compound as the original electrolyte. The caustic soda is used up only as it combines to form zincate of sodium.

Fig. 22. Copper Oxide Plate in Frame Without Zincs. BSCO Cell.

Fig. 23. Battery Oil for Gordon Cell.

They are especially suited for continuous closed circuit work, because of their low internal resistance and effective depolarization, the voltage at normal discharge rates being practically constant throughout the life of the cells.

Some of the purposes for which the Caustic Soda Cells are used:

Railway signals, crossing alarms, telephone train dispatching systems, telephone talking circuits, program and self-winding clocks and time recorders, fire alarm systems, mine signals, wireless telegraph, bell systems, annunciators, electric lights for motor boats and other small lighting systems, gas and gasoline engine ignition.

Battery Connections.

The information given on preceding pages regarding the current capacity and voltage of the different types of cells had reference to a single cell. It is possible to connect a number of them in different ways so that higher voltage or increased current capacity may be secured as desired from the battery consisting of several cells.

The ampere hour capacity and the voltage of the battery are dependent upon the nature and capacity of the individual cells and upon their method of connection. The current output of a given cell depends upon the area of the plates exposed to the electrolyte and upon the amount of the electrolyte, while the voltage is dependent upon the elements used. The same elements in a given electrolyte always produce the same voltage or difference of potential regardless of the size of the cell.

Fig. 24. Amalgamated Zinc Plate for R. R. Cell.

Fig. 25. Plate Assembly of R. R. Type. J, Brass Bolt Connecting Zincs and Forming Terminal; G. G. Hard Rubber Insulators.

Series Connection.

Series connection increases the voltage or electrical pressure by adding the voltage of the individual cells, but does not increase the number of ampere hours available over that of the individual cell.

The same chemical action takes place in each cell, as the same current must pass through each cell, they being connected in series. As the total current available from each cell is dependent upon the chemical action in the cell, then by increasing the number of cells in series on a circuit that has a given resistance, there will be an increase in the amount of current passing through the circuit, but will result in the cells becoming exhausted sooner. For this reason, it is important to determine before making an installation, just what voltage and current are neccesary to operate the apparatus in the circuit. Increasing the cells in series increases the voltage and current in the circuit, but decreases the life of the battery.

Series Connections are made as shown in Fig. 27, by connecting the positive terminal of one cell to the negative of the adjacent cell. It should be noted that in connecting any number of cells in series, their total internal resistance would be the sum of the internal resistances of all these cells.

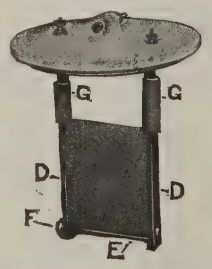


Fig. 26. Copper Oxide Plate and Frame Assembly, R. R. Type. G.G., Hard Rubber Insulators; D.D., Side of Copper Frame; E., Copper Bolt Connecting Frame; F., Copper Nut on Bolt.

As each cell of gravity type gives about 1 volt, the effective voltage across the terminals shown in Fig. 27, will be about 4, but the current, or rate of flow, which could be drawn from this battery is limited by the capacity of each cell and the internal resistance to about ¼ ampere. This current flow is also determined by the external resistance of the circuit through which the current passes. These terms referring to the electrical pressure, rate of flow of current and resistance, are explained in Lesson 1.

Multiple, Parallel or Bridging Connection.

These are different names for the same arrangement of the cells. This scheme, shown in Fig. 28, increases the ampere

hour capacity of the battery, but does not increase the voltage over that of the single cell.

The method of connecting amounts to the same thing as increasing the size of the plates of a cell to obtain a higher current capacity, as will be noted from the schematic arrangement shown in Fig. 28, B. The internal resistance of the battery consisting of cells in parallel is diminished instead of being increased as in the case of the series connections for the reason that the volume of the liquid through which the current would pass would be increased in proportion to the number of cells so connected. The resistance of a conductor is inversely proportional to the area of its cross section.

The total ampere hours available from cells connected in parallel is equal to the sum of the ampere-hour capacities of the cells so connected; the voltage is equal to that of the single cell; and the internal resistance is equal to that of a single cell divided by the number of cells in multiple.

Take for example, 10 cells each having a voltage of 1 volt, internal resistance .025 ohms and ampere hour capacity equal to

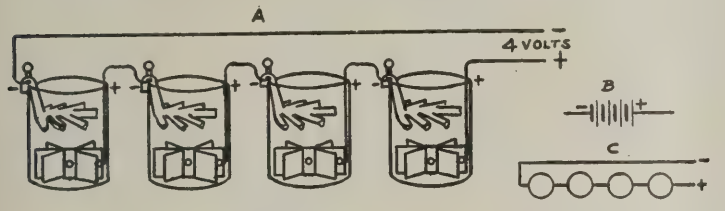


FIG. 27

200. If they are connected in series, the total voltage would be 10 x 1 or 10 volts, an internal resistance of 10 x .025 or .25 ohms, but the capacity is only 200 ampere hours, so that (from Lesson 1 for definition of watt-hours) the total watt-hours capacity of the battery would be 10 x 200 or 2,000 watt-hours. When connecting them in parallel, the total voltage would be 1, the internal resistance of .025 ÷ 10 or .0025 ohms and a capacity of 200 x 10 or 2,000 ampere hours, so that the total watt-hours capacity of the battery would be the same as above 1 x 2,000 or 2,000 watt-hours. Therefore, the total energy is the same in each case.

Series Multiple Connection.

Combinations of the above methods, namely, series and multiple or parallel connections, can be made as shown in Fig. 29, which builds up both the voltage and ampere hour capacity of the battery. The total voltage is determined by the number of cells connected in series and the ampere hour capacity by the number of cells in multiple. In Fig. 29, there are shown 5 in series and 6 in multiple. If we use the same type of cells as described above, 1 volt, 200 ampere hour and .025 ohms, internal resistance, then the voltage available would be 5, the ampere hours 6 x 200 or 1,200 and the total watt-hours available 5 x 1,200 or 6,000. This is the same as the total energy of the 30 cells at 200 ampere hours and 1 volt each, 30 x 200 x 1 or 6,000. The internal resistance of the battery is the resistance of an individual cell divided by the number of cells in multiple or .025 ÷ 6 and multiplied by the number of cells in series which is 5 or

$$\frac{.025}{6} \times 5 = .0208 \text{ ohms.}$$

These conditions above mentioned are determined by the laws of divided circuits, which are explained in Lesson 1.

When showing a battery in any wiring diagram it is advisable to represent it as in Figs. 27-B, 28-B or 29-C.

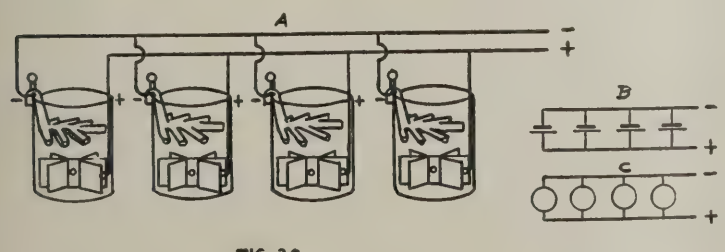


FIG. 28

Third Lesson.

17.—If you were to replace a gravity cell with a Gordon or an Edison BSCO cell, which terminal would connect in the place of the zinc of the gravity cell?

18.—Which terminal of the dry cell corresponds to the zinc terminal of the gravity cell?

19.—What characteristic of the gravity cell makes it very unfit for outdoor use in connection with signals, telephones or other devices in the winter time?

20.—When is it advisable to connect the cells in parallel and why?

21.—Assume that 10 cells, each having a rated capacity of 400 ampere hours, are connected in series on a circuit having a resistance of 50 ohms. If the voltage per cell available is .75, the internal resistance of each cell is .005 ohms, and the circuit is closed 8 hours each day, what will be the length of life of the battery? Show sketch of connection.

Fourth Lesson.

22.—What would have been the life of the above battery if the cells were each of 250 ampere hours?

23.—What would the life of the battery in problem 21 be if the circuit was closed for 3 hours each day through 100 ohms?

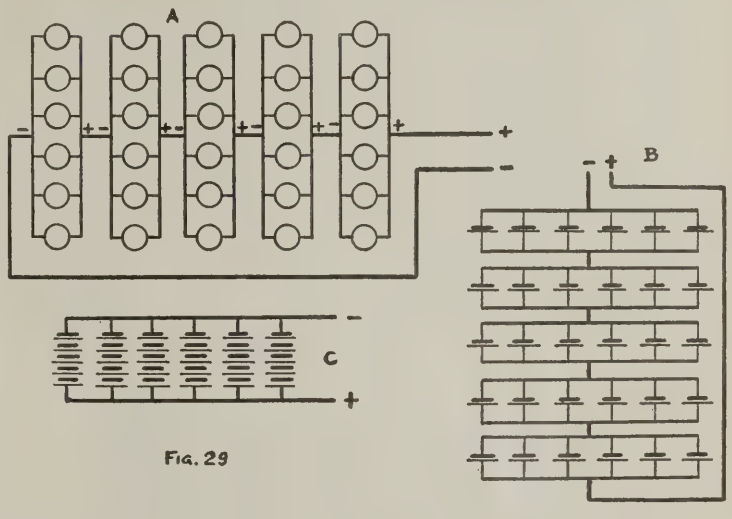


FIG. 29

24.—Assume that it will be convenient to renew the battery in a certain installation once every six months, that the circuit is closed for a period of 2 hours each day, requiring 2.1 amperes and 5 volts for operation. If the cells used are capable of furnishing current at .65 volt (*a*) what number of cells should be connected in series? (*b*) What capacity in ampere hours per cell would be advisable to install? (*c*) How should they be connected? (*d*) Show sketch of connections which should be made.

Fifth Lesson.

25.—If 2 Edison 400 ampere hour cells are connected in series and discharging at the rate of .2 amperes continuously, what will be the life of the cells?

26.—If these cells in problem 25 had been in multiple and the total discharge of the battery the same, what would be the life of the cells in days?

27.—Show sketch of a battery with 3 cells in multiple and 3 in series.

28.—If the nine cells in the battery connected as in problem 27 each had a capacity of 250 ampere hours and were capable of discharging at the rate of ½ ampere continuously at a voltage of .6, what would be the total current in the battery, the external resistance being

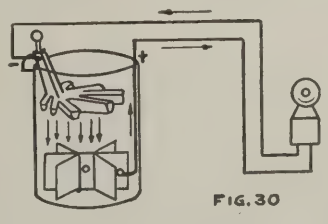


FIG. 30

adjusted to admit of this current on the voltage available?

29.—What would a voltmeter register if connected across the terminals of the battery in problem 28?

30.—How many days will the battery in problem 28 continue to operate?

LESSON 20

CONSOLIDATED TYPE L REGULATOR.

The consolidated type L. regulator, which was placed on the market in 1911, contains many novel features which are not found in other types of carlighting equipment. It is essentially a current regulator, in distinction from some of the combination current and voltage regulators previously explained in this course of lessons.

The voltage of the generator, or more correctly speaking, the generator current output, is controlled by varying the generator field current. As the generator speed increases due to increase in train speed, the generator field current will be automatically cut down to such a value as will maintain the generator voltage at the proper value to cause a certain current output to flow to the battery or lamps, as the case may be.

The regulator which produces this change in generator field current, so as to compensate for varying train speed, consists of the usual series solenoid through which

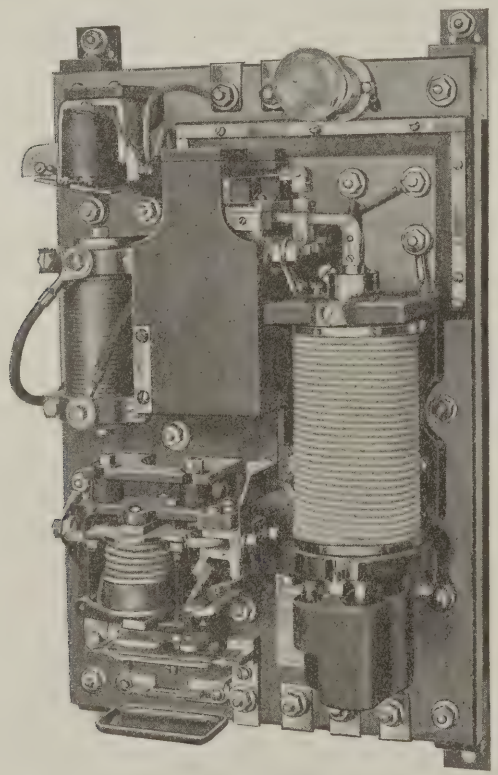


Fig. 116. Consolidated Type "L" Regulator Panel.

all, or a certain portion, of the generator current passes. The battery is always in circuit so if the generator voltage tends to rise by even a very small amount, the current which flows to the battery will tend to increase considerably. This increase in battery current, even though slight, will increase the magnetic pull of the series solenoid on its plunger, and this plunger will be drawn farther into the solenoid.

This solenoid is shown at the right of the regulator panel, Fig. 116, and it will be seen that the plunger connects to a rod which operates a rocking contact shoe device. This contact shoe is not clearly shown in the view of the panel board, but its principle is shown very well in the wiring diagram, Fig. 117, and also in the view of the lamp regulator, Fig. 118. On opposite edges of this shoe several thin laminations of brush copper are mounted on a bevel. These laminations are separated from each other slightly and extend about one-half inch from the rigid support of the shoe, so that they bend slightly under pressure and make a wiping contact. These copper laminations forming the contact brush on each side of the shoe are ground evenly to a curved edge so as to have a uniform rocker shape.

The generator field resistance consists of continuous metallic grids and contact is made from various points on this grid resistance to each of a series of thin metallic strips laid side by side and separated from each other slightly by insulating material, forming a flat commutator-like surface. They are mounted on top of the grid resistance element. The rocker shoe, explained above, rests on the face of this flat commutator, and the curved surface of the rocker shoe is so designed that it makes contact with only a small number of the commutator strips of the grid resistance at one time.

There are no springs to be adjusted in this equipment for the regulator is designed so that the weight of the plunger will require a certain magnetic pull, and consequently a certain amount of generator current flowing through the regulating coil. The output of the generator can be adjusted to any desired value by shifting the lower contact (G) of the adjusting shunt, Fig. 119.

Before the automatic switch closes the series solenoid is dead, and the plunger rests at the bottom of the coil. At this time the rocker contact shoe is tilted up so the heel only makes contact on the commutator strips of the generator field resistance. The generator resistance is then entirely cut out of circuit and the full generator voltage is impressed across the field. When the automatic switch closes, the current flows through the series coil to the battery and lamp, and the magnetism generated by this current picks up the iron plunger of the solenoid, This being connected to the rocker contact shoe, tilts it forward slightly causing the shoe to make contact with more of the contact strips of the field resistance. It still makes contact with the outside strip, however, so the field resistance remains cut out of circuit until the generator current builds up to the full value for which the regulator is set. When the train speed increases further, however, and the generator current tends to rise above the proper value, it will pull the plunger farther into the solenoid and cause the rocker shoe to tilt still further forward. This will gradually raise the heel of the rocker contact shoe so that it will no longer make contact with the first commutator strip. This will then cause the first grid of the field resistance to be cut into the field circuit, and so cut down the field current and reduce the generator voltage to normal value.

As the train speed increases further the contact shoe will tilt still farther forward and successively break contact with the other commutator strips, inserting their respective resistance grids into the generator field circuit. The generator field current is thus adjusted to such a

value as will always produce the proper generator voltage and current output at that particular speed.

An adjusting resistance provided as shown on the panel board of the diagram, Fig. 119, makes it possible to adjust the generator output to any desired value. This shunt also provides that the generator may be set so as to pick up any part or all of the lamp load as lamps are turned on. By referring to the wiring diagram, Fig. 119, it will be seen that the current, after passing through the automatic switch, divides, part going direct to the series solenoid of the regulator and part going to the point E, of the adjusting shunt. The lamp current

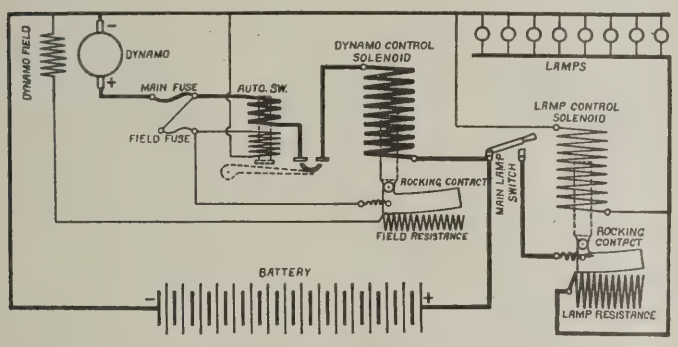


Fig. 117. Wiring Diagram of First Equipment Showing Principle of Rocker Shoe.

leaves the shunt at D and goes up to the positive main of the lamp switch, but some of the generator current continues through the shunt to the point G, and then connects direct to positive battery. This portion of the current which passes through the shunt to lamps and battery does not pass through the series solenoid so takes no part in the regulation of the equipment.

Adjustments.

By lowering the contact D of the shunt, the proportion of the lamp current shunted around the regulating solenoid will be decreased. This means that the increase in generator current when the lamps are turned on will be less. Similarly if the contact (D) is raised, more of the lamp current will be shunted around the solenoid, and if it is raised to the top of the shunt so that (D) makes contact with (E), practically all of the lamp current will be shunted around the regulating solenoid.

This will mean that if 10 amperes of lamp load is turned on and the generator output is 40 amperes, it will be increased to approximately 50 amperes, and if 20 amperes of lamp current is being used, the generator output will be increased to 60 amperes. If the contact (D) is as shown on diagram, Fig. 119, however, only about one-half of the lamp load will be picked up by the generator. Under this condition if 10 amperes of lamp load is turned on, the generator will increase from 40 to 45 amperes and if 20 amperes of lamp load is turned on it will increase from 40 amperes to 50 amperes.

The battery current may also be adjusted to any desired value by raising or lowering the contact (B). Lowering this contact will increase the resistance in the path of this battery current shunted around the solenoid so less current will flow through the shunt path, and the total battery current reduced. If it becomes necessary to increase the amount of charge given the battery, raise the contact (B) a few notches and this will reduce the resistance of the shunt path and increase the current flowing through it and so increase the total current to the battery.

It should be understood that the amount of current passing through the series winding of the regulating coil is always maintained constant, provided the generator is operating and the charge reducing switch open; but the amount of current passing through the shunt to the battery and lamps may be varied according to conditions as explained above.

The plunger of the regulating solenoid is fitted with a dash pot to prevent the plunger from surging up and down with the car motion or from any other cause. This dash pot does not use oil or glycerine, but is designed simply to operate by air friction.

Stop Charge Device.

When the battery becomes nearly charged its voltage will rise rather rapidly, and when this reaches 40 volts it will energize the magnet of the switch shown at the upper left hand corner of the regulating panel, Fig. 119, to such an extent that it will attract the armature, and in doing so closes another circuit which allows current to flow through the shunt winding of fine wire placed inside of the main regulating series solenoid. This shunt coil consists of a large number of turns so that although this current is of small value, the ampere turns of magnetizing force of this coil (ampere turns are the number of amperes times the number of turns) is very large, in fact nearly equal to the ampere turns of the heavy generator current which flows through the comparatively small number of turns in the series coil.

When this charge reducing switch closes, the magnetism generated in the shunt coil of the main regulating solenoid simply replaces an equal amount of magnetism which would ordinarily be required from the series coil in order to lift the solenoid plunger, and this reduces the generator current from say 40 amperes down to 5 amperes.

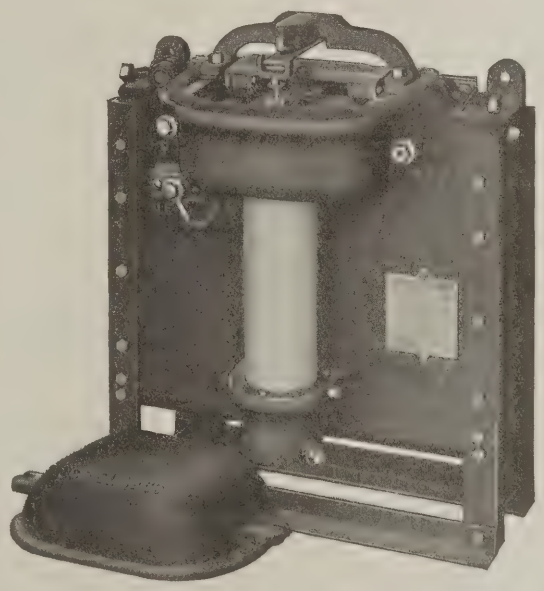


Fig. 118. Type "L" Regulator with Cover Removed.

An example will probably make this point clear: Assume that the series winding of the solenoid consisted of 100 turns and that the regulator was adjusted to deliver 40 amperes charging current with no lamps lighted. This means that it takes practically 4,000 ampere turns (40×100) to lift the plunger of the solenoid.

Now assume that the batteries have become fully charged and the charge reducing switch closed, there will be, say 1 ampere current, flowing through the fine winding of the shunt coil. If we assume that this coil has 3,500 turns, the 1 ampere of current passing through the 3,500 turns will generate 3,500 ampere turns of magnetizing force.

But as it only requires 4,000 ampere turns to lift the plunger of the solenoid, and 3,500 ampere turns are furnished by the shunt coil, there will only be 500 ampere turns then required from the series coil of the solenoid.

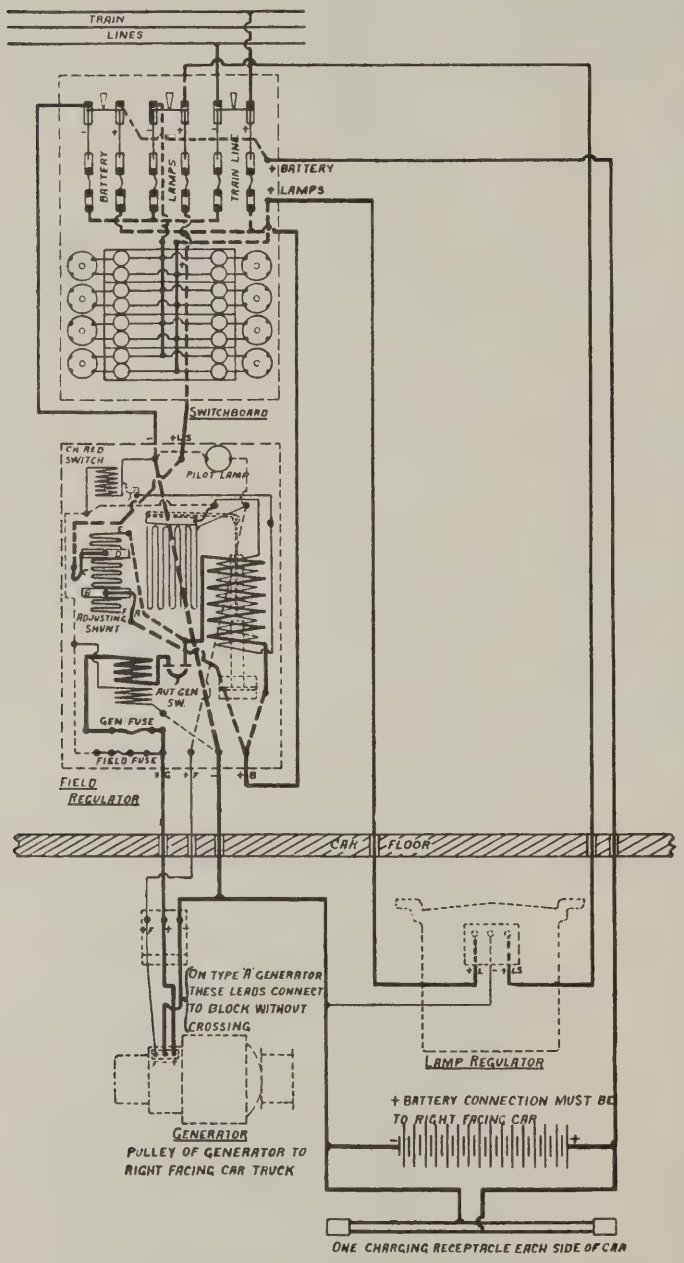


Fig. 119. Wiring Diagram of Installation in Car.

Now 5 amperes flowing through the 100 turns of the series coil will produce this required 500 ampere turns, so when the stop charge relay, or charge reducing switch, closes, the charging current delivered by the generator to the battery will be reduced from 40 amperes to 15 amperes. These values are, of course, only assumed for explanation, the equipment can be designed to give any amount of reduction in battery charge.

This charge reducing switch can be set at a low enough voltage so that it will always operate even though the battery be warm and the voltage at the end of charge low. The continued charge at the reduced value will then be sufficient in every case to bring the battery up to full capacity in a very short time.

In case of an open circuit in the battery the generator voltage will rise and operate the charge reducing switch which will energize the shunt coil of the regulating solenoid and keep the generator voltage down to normal value.

The Lamp Regulator.

The lamp regulator, shown in Fig. 118, and also in the diagram, Fig. 117, is very similar in construction to the generator regulator as explained above. As the amount of current to be carried is much larger, however, the grid resistances and all other parts of the lamp regulator are of heavier construction. The regulating solenoid contains many turns of fine wire and is connected directly across the lamp terminals. If the lamp voltage tends to rise above normal the solenoid will lift its plunger and tilt the rocker contact shoe, inserting more resistance in the lamp circuit and reducing the voltage on the lamps to normal value.

Dynamo.

The dynamos furnished with type L. regulators are types known as type "D," 4 k. w. and type "F," 2 k. w. A worm gear is cut in the end of the armature shaft and this drives a specially designed cam which operates the pole changing switch. This pole changer was fully explained in our Lesson No. 10, November, 1912. Interpoles are mounted midway between the main fields of the generator, and the entire generator current passes through the windings of these interpoles. This generates a magnetic flux which entirely neutralizes the armature reactions due to the generator current flowing through the coils to the armature, and so produces sparkless commutation at all loads and all speeds and whether the generator is running in either direction. A notable feature of these dynamos is the method of securing the armature coils in place on the armature, metallic ridges being employed instead of band wires, so that in case a bearing wears out and lets the armature down on the pole shoe, a smooth surface will be presented and there will be no damage done to the brush rig by loosed band wire.

No. 2 and No. 3 Ralso Receptacle and Plug.

These receptacles and plugs were designed to meet the demand for a thoroughly reliable, heavy duty receptacle and plug for battery charging, portable motors in shops, and other places where portable machinery is used. They

are especially desirable for portable drills, riveters, grinders, vacuum cleaners, and elevators.

The receptacle consists of two heavy porcelain blocks fitted with heavy phosphor bronze spring contacts. The receptacles are mounted in an outer heavy cast iron case on an angle to facilitate the insertion and withdrawal of the plug when installed upon a flat surface. No. 2 receptacle is rated at 30 amperes and No. 3 at 60 amperes, 1220 volts.

Methods of Charging Storage Batteries.

To The Editor:

I have read the report of the committee on "Methods of Charging Storage Batteries" in your July issue and think the subject has been handled in a most thorough manner.

Under the head of "Axle Generator Service" the committee reports that so far as they are aware ampere-hour meters have not been used for controlling the charge to battery. Since seeing this report I had an occasion to install an ampere-hour meter on a car in connection with an axle generator system.

The meter was of the resistor type and was fitted with the auxiliary circuit contact device, so when hand returned to zero it was intended to trip a circuit breaker, opening the battery circuit. This, of course, being objectionable with the axle equipment, the circuit breaker was omitted. It then occurred to me to use this auxiliary circuit to reduce the charging current when battery was completely charged. Therefore I connected the auxiliary contact circuit so as to shunt out a small portion of the resistance which is in series with the charge reducing relay coil, thereby causing the relay to operate when the ampere-hour meter showed full charge and the hand returned to zero. This worked out to satisfaction and proved much more dependable than relying on the relay alone. Of course the meter being of the resistor type was compensated so as to allow for the efficiency of the battery.

In using a system of this character the reliability depends on the correct operation of the meter and consequently the meter should be checked carefully before placing in service and when in service should be checked frequently.

This method could be employed on all equipments with slight modification, and in event that regulator panel is not provided with a relay for decreasing charging current, a small resistance could be placed in series with the coil controlling field resistance and so arranged that the auxiliary contacts in the meter could control this resistance as desired.

Under the heading of "Head End System" the committee recommends class "C" operation, but remarks that it would require close observation on the part of the attendant, so as to decrease charging current as batteries are automatically cut off. Under the best conditions a certain portion of personal attention cannot be omitted, but I think there could be some modification which would decrease the amount of personal attention necessary and improve operating conditions.

In connection with the ampere-hour meter the circuit breaker would only perform one function automatically and depend on the attendant to restore the circuit breaker to proper conditions for charging.

Now, why not replace the circuit breaker with a stop charge relay operated by the ampere-hour meter?

This would permit the battery to be automatically disconnected on completion of charge and to be automatically restored to charging circuit when there has been a slight discharge. This, of course, keeps the battery in a fully charged condition and prevents overcharging, but does not permit the battery to receive a complete cycle of charge and discharge.

To do so the ampere-hour meter should be arranged to restore the relay to charging position when discharge has reached a certain predetermined limit. This would require a slight alteration to the present style of meter.

In operation the attendant would be required to maintain a constant voltage on the train line and as each set of batteries becomes charged, the charging current would decrease accordingly.

Very truly yours,
A. V. Westervelt.

Electric Dept.
B. & O. System,
Baltimore, Md.

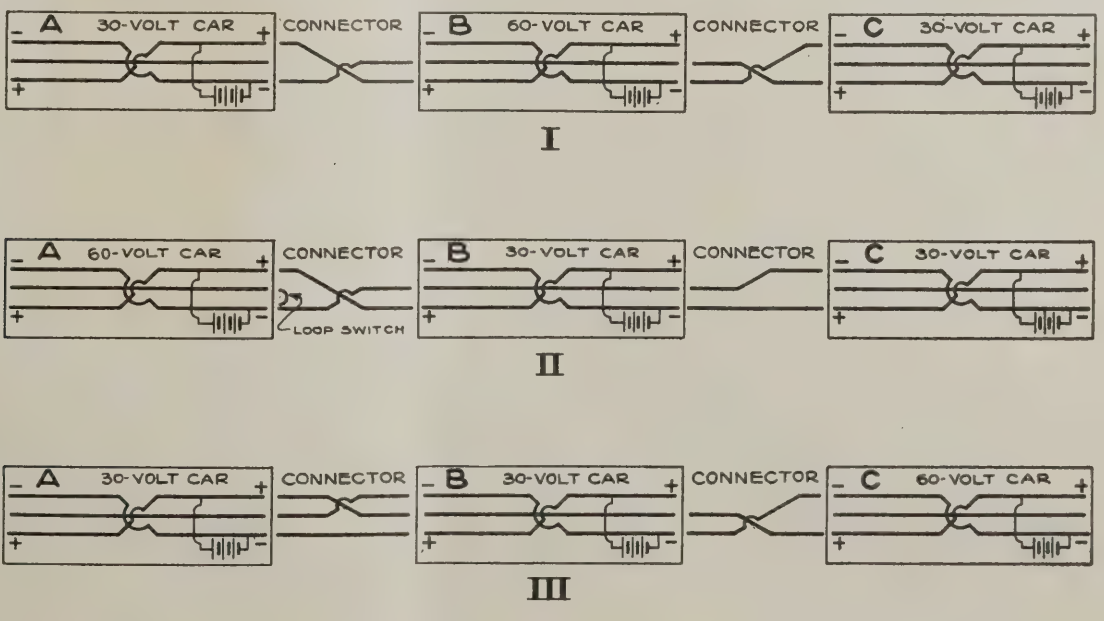
Practical Stunts

We pay $1.00 *for each of the practical stunts published in this section. Send in your ideas—in your own words and with just a rough pencil sketch if necessary.*

Train Lining 30 and 60-Volt Cars.

In previous practical stunts we have seen how 30-volt cars, even though separated by one or more 60-volt cars, could be train lined and we can now extend this idea a little farther and by connecting two 30-volt cars in series with each other, connect the two in parallel with a 60-volt car or head end train line.

Fig. 1 of the accompanying illustration shows two 30-volt equipments, which are both assumed to be in bad order, connected in series with each other and the two are then fed from the 60-volt axle equipment which is in



good working order. By connecting the positive of the 30-volt car "A," Fig. 1, to the positive of the 60-volt car, "B," and the negative of the 30-volt battery car, "A," to the neutral of the 60-volt car, "B," and at the opposite end of the 60-volt car this same neutral connecting to the positive of the 30-volt battery on car "C," and the negative of this battery to the negative of the 60-volt car, the same amount of current must then pass through car "A" as through car "C," but this current is divided between battery and lamps, so the lamps in these cars will not be strained or damaged in any way by the series arrangement.

Fig. 2 shows two 30-volt cars which have failed, connected in series and placed in parallel across the 60-volt head end train line. The connections here are very similar to those explained above.

In Fig. 3 is shown the case where we have two disabled 30-volt cars in the middle of a 60-volt head end train or between two 60-volt cars which latter are to be train-lined together. The 30-volt cars are connected in series as explained above and connected to the 60-volt circuit. The run around or return loop is closed at the rear of the car ahead of car "A." The positive train line connects to the positive of car "A," but the negative of this car connects to the neutral of car "A" thence to the negative of car "B." The negative of car "A" connects direct to the positive of car "B," which is the ordinary series connection. The 60-volt car "C" then connects to the negative of car "B," which is the positive of the 60-volt train line and the negative of "C" connects to the negative of "B," which is the negative of the 60-volt train line.

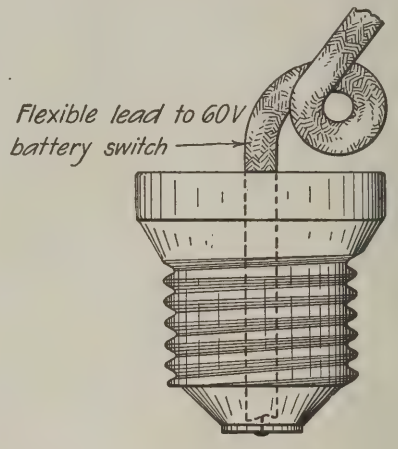
Although these may be considered as somewhat unusual cases of trouble, they are occasionally bound to exist, and by simply shifting the train connector leads in the proper manner serious cases of trouble may be completely remedied. W. M. W.

Axle Light Cars on City 110 Volt Service.

It sometimes occurs that Pullman cars are laid over at a terminal for several days, during which time they are used by passengers. This means a continual discharge every night, with little or no opportunity of charging. In some cases the battery and generating equipment have been entirely disconnected and the car lighted from the 110-volt a. c. or d. c. circuit.

At such times heretofore both battery and generator field have been permanently disconnected and the lamp regulator short-circuited. By following out the accompanying diagram with the U. S. L. system, the equipment can be very easily prepared to receive the city current without disconnecting any of the wires below the car.

All that is necessary is to remove the train line fuses, change the lamp, block the lamp switch open and run wire connections from the train line to the



Special Connector Plug for Fans.

blades of the lamp switch as shown and disconnect the type H relay, so that the high voltage will not be impressed across the relay coils. By removing the fuse plugs in the fan circuits and inserting a special fuse plug with a flexible lead soldered to the center contact of the block as shown in the accompanying diagram, the fans may be connected direct to the battery circuit and fed from the battery, while the lamps in the car are fed from the city 110-volt circuit.

Repairing Generator Suspension Loops.

The loops of parallel link suspensions tend to wear out rapidly at the holes where they are supported by the link cotter pin. These loops are now finished with renewable bushings, but the earlier loops were not and the wear in service in many cases has been found to be excessive.

This can be repaired by welding a plug into the worn-out end of the loop which can be re-trimmed large enough to take a bushing made from case hardened steel tubing. When this bushing becomes worn, it can be driven out and replaced with a new one without removing the dynamo from the suspension.

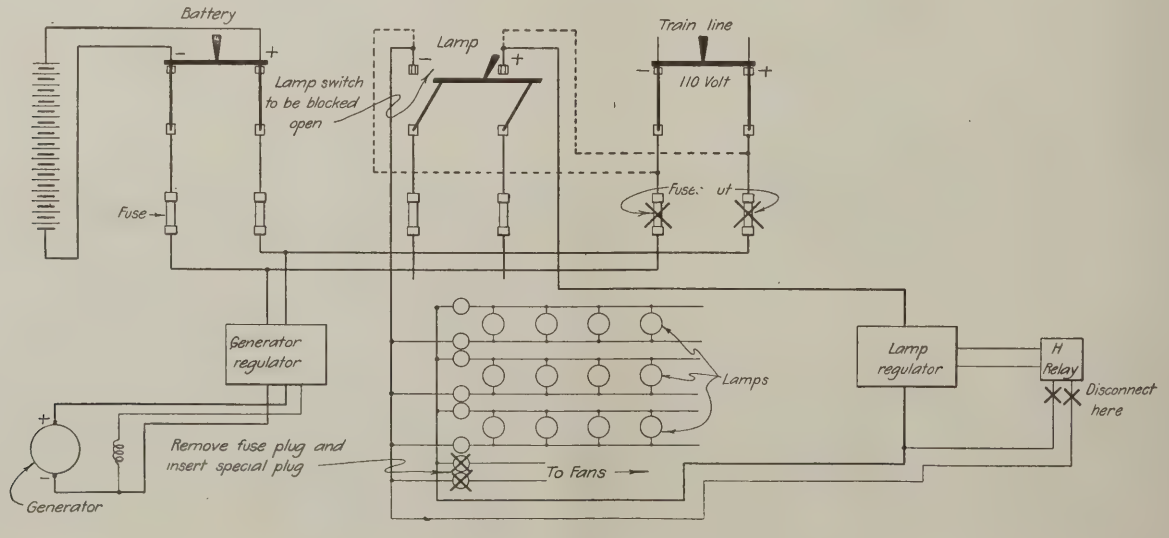


Diagram for Connecting Axle System to City Service.

Prize Question Box

Announcement.

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

This ought to stir up some mighty interesting information, for we can all ask questions even though we don't have a big line of practical stunts to submit.

The names of the prize winners will be published each month and all the questions submitted will be answered by us in the same issue. (If we can't answer them ourselves, we will find somebody who can.)

Better send in your questions now, while you think of it.

First Prize

Field Fuse Trouble.

Question. What conditions could come in an axle lighting system to cause the shunt field fuse to blow? S. W. E.

Ans. When a shunt fuse blows, it invariably means that the current which is passed through that fuse has been of abnormally high value. This may be due to several different causes: (1) If the equipment does not have a stop charge or voltage controlling device, or if such device is out of order, an open battery circuit will cause the generator voltage to rise to an abnormally high value when the train is traveling at high speed. This will cause an abnormally high current to flow through both the lamps, if any are turned on, and the generator field and will usually blow the field fuse.

(2) If the generator field becomes short circuited or grounded in two places the current flowing through the field fuse would be the sum of the normal field current plus the short circuited or grounded current; the sum of these two would usually be sufficient to blow the field fuse.

(3) It sometimes occurs that the regulating mechanism fails to work, due to the dash pot sticking or to other causes so that the proper amount of resistance is not inserted in the field circuit as the train speed rises. This will allow the generator voltage to rise with the train speed, and of course the generator field current will rise with the generator voltage until it finally becomes heavy enough to blow the fuse.

Second Prize

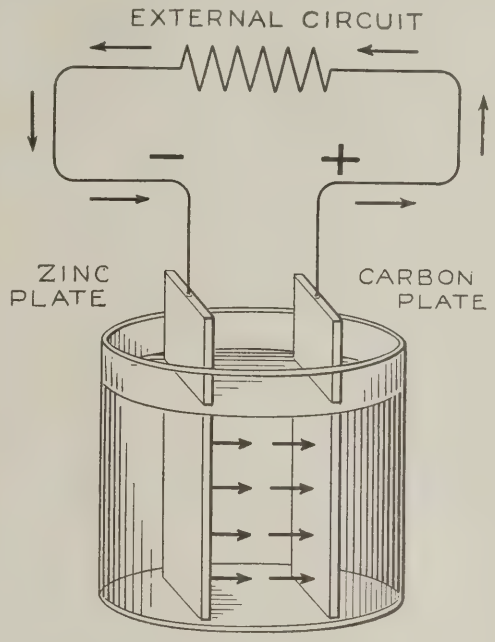
Positive and Negative Elements.

Question. In the table on Page 103 of the Pennsylvania "School of Electricity" in your August issue a list of metals is given, those at the head of the list being strongly positive, and those at the last, least so. Now, you further state that if any two of these metals are used in a battery, the one given first in the list will be positive, and the one given below it in the list would be negative.

I notice zinc is given near the head of the list, and carbon near the end; yet in a battery the zinc is the negative pole, and carbon the positive. Similarily you give lead near the head of the list and lead peroxide at the tail end; yet in a storage battery the lead plate is the negative, and the peroxide plate positive. Isn't there something wrong with this part of the lesson? C. W. P.

Answer. In the third paragraph following the table referred to this point you bring up is explained briefly, but evidently the subject needs a little further explanation. When we speak of a metal being "electro-positive" in a solution we refer to its electro-chemical activity in that particular solution. All metals are electro-positive to a solution, only some more so than others. Modern science calls this ionization, but we'll not get into theoretical ground any deeper than necessary.

Zinc is said to be more strongly electro-positive than carbon because it is more active electro-chemically than carbon. The term "positive" has no reference to the direction of current flowing in the external circuit. The zinc plate, being more strongly positive to the electrolyte than the carbon plate will cause the current to flow (when the external circuit is closed) from the zinc plate through the electrolyte to the carbon plate, and



thence through the external circuit back to the zinc pole as shown in the accompanying diagram.

From this diagram, it will be seen that the zinc plate, which is more strongly positive chemically, is really the negative pole of the battery when the battery is considered as a whole in reference to the external circuit.

Third Prize

Iron in the electrolyte.

Question. Why will iron in the electrolyte of a lead storage battery injure the battery? E. J. G.

Answer. The reason why iron injures the plates of a battery is not definitely known at the present time. Most metals when found in the electrolyte as an impurity go to the negative plate and the metal is deposited there; iron, however, seems to attack the positive plate more than the negative. The first indications are a light muddy color of the positive plate accompanied by a loss in capacity. On test with cadmium, moreover the negative plate is found to be inefficient. The reason *why*, however, is probably due to secondary reactions. That's easy to say, but much less easy to understand, so we will try to explain.

When even a small piece of iron rust or iron in any form, falls into the sulphuric acid electrolyte it immediately dissolves, forming sulphate of iron. Iron has the peculiar property of forming two kinds of salts, ferrous sulphate $Fe_2 (SO_4)_2$ and ferric sulphate $Fe_2 (SO_4)_3$ and these salts are readily changed from one to the other. It will be noticed that the ferric sulphate contains more (SO_4) than the ferrous sulphate does.

It is very probable that when such a salt, which has the property of taking on sulphate or giving it up readily, finds its way into a battery, it will act as a

carrier for transferring the oxygen from the charge positive (Pb O_2) to the negative plate (Pb) changing both plates to (Pb O) and so discharging the battery.

Problems in Ohms Law

To the Editor:

I take pleasure in submitting a problem, which I once had given to me and had the good fortune to solve. It looks as if there were some catch about it, but there is not. Would be pleased to see you put this in your question box.

A generator on no load shows a voltage of 10 volts at its terminals when measured by a voltmeter of negligible current carrying capacity.

The same generator when short circuited through an ammeter of negligible resistance produces a current of 10 amperes.

What resistance should be placed in the external circuit to make maximum current flow? W. L. Bliss.

Answer. By way of explanation it may be said that this is not a practical problem, but is one which nicely illustrates the way that Ohms Law may be applied. If 10 volts were generated in the circuit, and this 10 volts on a dead short circuit of the generator caused 10 amperes current to flow, the resistance of the generator is then the voltage divided by current (10 divided by 10) or 1 Ohm.

Now then when a resistance is placed on the external circuit, and current allowed to flow, the total resistance will be 2 ohms, and the current, volts plus the resistance in the armature. The problem is then to figure out a resistance which will absorb the greatest amount of power in this external circuit. This will be a maximum when the resistance of the external circuit equals the resistance of the generator, 1 ohm. If a higher resistance is used, the current will be reduced and the total power in the resistance less. With a resistance of 1 ohm in the external circuit, the total resistance will be 2 ohms, and the current, volts divided by resistance (10/ 2) equals 5 amperes; the voltage drop through this external resistance would be the product of current $\times$ external resistance, or 5 volts, and the power absorbed, the product of current $\times$ volts (5×5) or 25 watts.

With 2 ohms resistance in the external circuit the total resistance will be 3 ohms, the current would be

$$\frac{E}{R}, \quad \left(\frac{10}{3}\right) \text{ or}$$

3 1/3 amperes, the voltage drop through the external resistance would be $C\times R$ ($3\ 1/3\times2$) or 6 2/3 volts, and the power absorbed in the external circuit would be the product of current $\times$ volts ($6\ 2/3\times1\ 1/3$) or 22 2/9 watts. If resistance of only 1/2 ohm is placed in the external circuit, the total resistance will be 1 1/2 ohms, the current 6 2/3 amperes, the voltage drop through the external resistance 3 3/10 volts, and the watts absorbed $2\ 1/3\times6\ 2/3$ or 22 2/9 watts.

Therefore it is evident that if the resistance in the external circuit be made either greater or less than the resistance of the armature (1 ohm) the power absorbed in that resistance will be reduced.

To The Editor:

I read with considerable interest, the article in the last issue on the subject of Primary Batteries. It occurs to me that a better definition of a dry battery than that which you published, would be as follows:

"A dry battery is so called because it always remains wet, to distinguish it from a wet battery that usually dries up."

W. L. Bliss.

Car Lighting Club Talk.

Talk before meeting of St. Louis Car Lighting Club by Geo. B. Colegrove.

As I understand it, this Association was organized with the idea of bringing together the men that handle the equipment, the foremen in the yards, and the heads of the departments interested in the train lighting business, working in harmony to boost the axle lighting game with the idea of getting the best possible results and improving the service.

We must demonstrate that it is cheaper and much more desirable to light the cars with electricity than with gas, and much safer. For a number of years we have been making this fight and with the improvement of the axle lighting devices in the past few years it looks as though we were going to win out. I believe we are about to see the passing of the gas lighted cars on all first class trains and it will be but a few years when the less important coaches will be electric lighted.

It is necessary for the men to take a personal interest in this work if they expect to make electric train lighting a success on their road. The Electrical Engineer or Chief Electrician will not be successful in the operation of train lighting unless he has the support and co-operation of all of his men, as in no other line of electrical work is he so dependent on honest conscientious performance of duty. It is unnecessary for me to point out to you in what manner a person can neglect or slight his work and still get by with it, but it will all show up in the performance of the equipment and the cost of maintenance.

On our road we have tried to create a feeling among the men of loyalty to the department knowing that we would have their interest to promote as well as our own to protect. We wish the men to feel that they can come to us with their troubles and we will try to help them out instead of criticising and encouraging deception. We appreciate the fact that no-one is absolutely infallible and mistakes will be made, but we want the men to acknowledge their mistakes rather than try to cover them up. I believe this policy bears fruit in dollars and cents as well as insuring better service to the railroad.

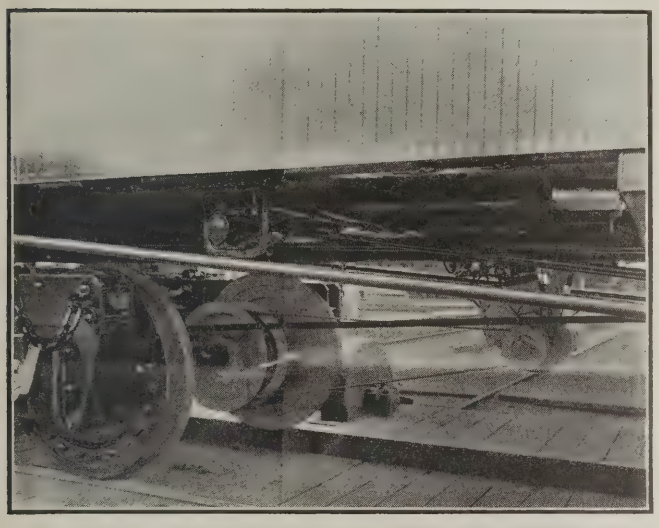
We have operated our electric lighted cars for the past year at a cost of $17.00 per month. Our percentage of light failures was two-tenths of one per cent. This was less number of light failures than occurred on similar number of gas lighted cars in same service. The U. S. Government Mail Service requested ninety-nine and one-half per cent efficiency but compromised on ninety-nine per cent. With the use of train lines and the equipping of trains with axle devices there should be no excuse for light failures or necessity for auxiliary lighting. The train crews must be educated to handle the equipment en route, such as renewing fuses, putting up train connectors and notifying electrical inspectors of troubles that develop.

In electric train lighting there are but three things to consider. Safety, service and economical operation. The first two should not be lost sight of in considering the latter. It is false economy to give poor service or to allow an equipment to remain in service where the suspension is badly worn and could be considered in any way unsafe. The dropping of an equipment might and probably would derail a train as has happened on a number of roads causing enough damage to have paid for the shopping of all of their electric lighted cars as well as jeopardising the lives of a great many people. As an illustration, I wish to call attention to what was done on the Illinois Central in the

way of making good their motto of safety first, (not meaning the Safety Equipment.)

We had a couple of side suspension irons break, due to faulty application. Where the side irons passed through the end sill of steel truck the irons were not secured allowing them to pound and vibrate; they became crystalized and eventually broke. We had every one of these cars shopped and heavy side braces applied in addition to the original suspension irons. The derailment of a single train would have cost more than the expense involved in making these equipments safe.

To operate equipment successfully it is necessary



New Truck Design Showing Absence of Brake Rigging.

to have repair parts in stock and if you have to borrow or beg to get material to make repairs the service must necessarily suffer. You may show a comparatively low cost of maintenance but you will also show low average of efficiency and the electric lighting of cars gets a black eye. The advocates of gas lighting will claim that the electric lights cannot be depended on and your records for light failures will very likely bear them out.

On our road we believe it is good policy to pay our men good wages in the car lighting field as well as in other electrical lines so that when we develop a good man we will have some assurance of being able to keep him. I know of some roads that have had a great deal of trouble keeping their men for the simple reason that when they educate a man to a point where he is of some value to them he can get more money with other roads or in other lines of the electrical business and as a consequence the service is poor on this road and their costs for lighting are higher than they should be. The men do not take the same interest that is taken by the man who feels that he is getting a fair wage. In no line of electrical work is the work more disagreeable or dangerous than that of car lighting and I sincerely believe that it is poor economy to underpay this class of help where we must look for the bright energetic intelligent young man capable of using his brains as well as his hands.

Every city that has enough car lighting men to support a club should organize for the same purpose this club is meeting. While any club purely local in scope cannot carry much weight outside of their immediate territory, the Association of Railway Electrical Engineers embraces in its membership all men employed in the electrical work on steam railways and all of the members of this organization should put in their application to the older Association.

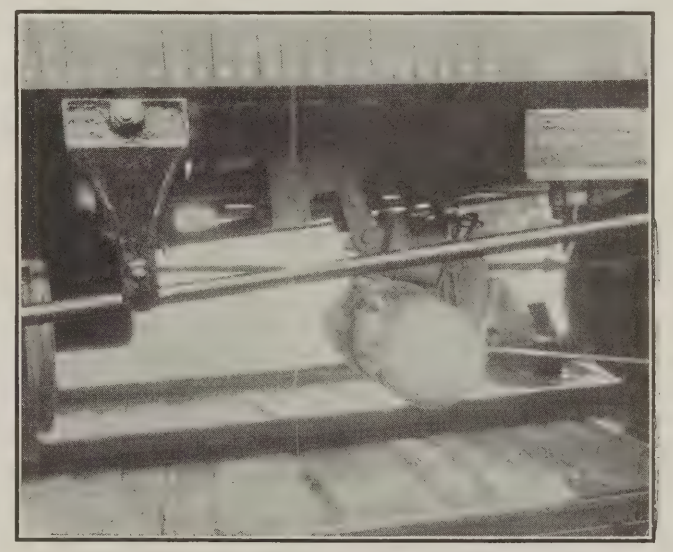
NOVEL TRUCK DESIGN.

With the new steel car construction, particularly with those cars of the fish-belly type, the question of proper clearance for the axle generator, axle pulley and belt sometimes becomes a very serious problem. In many cases, in both the new steel cars and the old style wood construction, the carlighting belt has come dangerously near to the brake rigging. When the brakes are set, the strain of braking lowers or raises the brake beam slightly, and sometimes this rubs on the belt with the result that fastener is torn off and the belt lost.

The accompanying illustrations show a novel truck design in use on the Canadian Pacific Railway which entirely eliminates all trouble from this source. The brake rigging is all removed from the end of the truck to the center by changing the brake lever design, and this leaves the entire end of the truck open for belt and pulley inspection and repair.

It will be noted that the generator is suspended from the car body by means of a double link suspension which is adjustable. The pull of the belt draws the belt to an out-of-plumb position. When the speed of the train gets above a certain value, however, the generator will be drawn still farther out of plumb, thereby loosening the belt tension slightly, and the belt then slips just sufficiently to drive the generator at a constant speed regardless of how high the train speed goes. The dynamo then does not receive the vibration to which it is ordinarily subjected when mounted directly on the truck. The dynamo and axle pulley are then freely accessible and a belt can be applied with ease.

Although this particular dynamo suspension would not operate satisfactorily on our swivel trucks when rounding curves, a modification of this truck design, containing the fundamental principle of removing the brake rigging from the end of the truck would have many advantages from the carlighting point of view. The saving in carlighting belts torn off by fouling the brake beam would undoubtedly be found to be very marked and fully warrant this change in truck design by the mechanical department.



Generator Suspended from Car Body by Double Link.

EDUCATIONAL PAMPHLET ON GOOD LIGHT.

The MacBeth-Evans Glass Company, Pittsburgh, Pa., have sent us a new pamphlet entitled "Good Light," which is profusely illustrated with installations of well lighted interiors. Indirect lighting plays an important part in these views.

Another 2,200 Miles of New Telephone Train Dispatching Circuits

Large and small railroad systems throughout the United States are continuing to make additions to their telephone train dispatching circuits, while others, inspired by the success attendant upon the adoption of this method of traffic control by the pioneers in this work, are preparing to install similar equipments.

The Erie Railroad has recently equipped four of its divisions with telephones and selective signaling apparatus, which enables the dispatcher to call any way-station on the line without calling others on the same wire. Two of the circuits extend from Susquehanna, Pa., to Hornell, N. Y., on the Susquehanna division, a distance of approximately 140 miles. One of the circuits will have 46 way-stations equipped with signaling and talking apparatus and will be used exclusively as a train wire for carrying messages and orders relating directly to train dispatching. The other circuit, running parallel to the train wire, will have fifty-one way-stations equipped and will be used as a message wire for carrying messages relating to routine work and matters other than train control. The dispatcher is located at Hornell.

On the Cincinnati division of the Erie a thirty-six way-station train wire and a twenty-seven station message wire extend from Marion to Kent, O., a distance of approximately 115 miles, with a dispatcher at Marion. On the Buffalo division a train wire and message wire will be operated between Hornell and Buffalo, N. Y., a distance of about 95 miles. There are eighteen way-stations on the train wire and thirty-three on the message wire. The dispatcher for this division is at Buffalo. On the Lima and Chicago division two train wires and two message wires will be operated. One train wire of fifteen way-stations extends from Hammond to Huntington, Ind., a distance of 122 miles, and the other of fifteen way-stations, from Marion to Huntington, a distance of about 130 miles. One message wire of twenty-two stations extends from Aldine, Ind., to Huntington, a distance of about 75 miles, and the other from Elgin, O., to Huntington, a distance of about 65 miles, with sixteen stations equipped. The dispatcher for these wires is located at Huntington.

The mileage equipped on the Erie totals over 700 and the number of stations approximately 300. Way-station equipments consist of Western Electric No. 102 type selector sets and desk stand telephones. Wherever train and message wires enter the same station the selectors are so numbered and adjusted that they can be switched through test panels from one wire to another in case of emergency. Portable telephone sets have also been furnished the various train crews on the divisions equipped for telephone dispatching.

The Pennsylvania Railroad has also installed several additional circuits on a number of divisions. The Jersey City freight yards have been completely equipped with telephones and selective signaling apparatus. This circuit, which has ten way-stations, extends from the freight train directors' office in Jersey City, where the dispatcher is located, to Waverley, N. J. Two other circuits, a train wire and a message wire, the former equipped for thirteen and the latter for seventeen way-stations, are operated from Jersey City to Newark. Three circuits have also been installed over the Pennsylvania lines west of Pittsburgh, with equipments for eleven, twenty-six and eighteen way-stations, respectively. A seventeen station train wire from New Florence to Derry, Pa., a twenty station message circuit on the Monongahela division and a fifteen station train wire on the Middle division from Altoona to Thompsontown are also in operation. Western Electric No. 101 type selector sets are used throughout. The Pennsylvania, on the divisions west of Pittsburgh, has gone very extensively into equipping its lines with block telephones. These are of the wooden wall type and are in the shelter boxes at sidings and then connected to metallic telephone circuit lines going to the nearest train wire way-station.

Two divisions of the Cleveland, Cincinnati, Chicago & St. Louis Railroad, more familiarly known as the "Big Four" route, will be equipped with Western Electric selectors and telephones. One train wire will cover the east end of the Chicago division extending from Minneapolis to Kankakee, Ill., where the dispatcher will be located. There will be thirty-four way-stations equipped on this circuit, which is approximately 150 miles in length. The other circuit will be a train wire on the eastern end of the Peoria and Eastern division and will operate between Indianapolis, Ind., and Springfield, O., a distance of 140 miles.

The Northern Pacific has also placed orders for equipment to be used between St. Paul and Duluth, Minn. A train and a message wire will parallel each other and will be arranged to furnish a through telephone circuit between the general offices at St. Paul and Duluth. The distance covered is approximately 160 miles and forty-five way-stations will be equipped. The train wire dispatcher will be at St. Paul, while the message wire will be arranged to call from both ends.

The Denver & Rio Grande Railroad will shortly install a telephone train dispatching circuit. Approximately 330 miles will be equipped over the division extending from Ogden, Utah, to Grand Junction, Colo. The train wire will be split into two parts, with the dispatchers at Salt Lake City and Helper, Utah. A total of forty way-stations equipped with selectors and telephones and forty-five way-stations equipped with telephones only will be operated over the train wire.

Five new circuits will be added to the lines of the Buffalo, Rochester & Pittsburgh Railroad. On the Middle division a thirty station train wire will extend from Du Bois, Pa., to East Salamanca, N. Y., a distance of 97 miles. On the Charlotte division there will be an eleven mile, twelve station train wire from Charlotte to Lincoln Park, N. Y.; on the Pittsburgh division an eighty-three mile, twenty-six station train wire from Du Bois to Butler; on the Indiana division an eighty-six mile, twenty-two station train wire from Du Bois to Josephine, Iselin and Punxsutawney, Pa., and on the Clearfield and Mahoning division, a twenty-seven mile, twelve station train wire from Clearfield to Du Bois. Western Electric selective signaling and telephone equipment will be used throughout.

The Waco, Dallas & Corsicana Electric Interurban Road, of Texas, a new branch of the Southern Traction Company, will be one of the first of the southern electric interurban railroads to adopt telephone train dispatching methods for traffic control. Two branches will be equipped with selective signaling and telephone apparatus, one from Dallas to Waco, a distance of about 100 miles, and the other from Dallas to Corsicana, a distance of about 60 miles. A train wire and a message wire will be installed over each branch and a total of thirty-four way-stations equipped.

These equipments which have been detailed add over 2,200 miles to the continually increasing mileage of telephone train dispatching circuits. This makes a total of approximately 75,000 miles of road so equipped and speaks volumes for the success experienced with this efficient method of train control.

General News and Personal Mention

C. W. BENDER.

You never would think it to look at his smiling boyish face, but "Claude" Bender has done railroad work for the past twenty-four years. He was born in Altoona in 1876 and after a public school education entered the employ of the Pennsylvania Railroad in the electrical department at their Altoona shop in 1889. The following thirteen years he was employed in building and assembling telegraph instruments, machinist work, work on arc lamps, motors, generator repairs, wiring, construction and operation of power plants, and the last year of this period he was employed in the drafting room.

C. W. Bender.

In June, 1902, he resigned from the Pennsylvania to accept a position as electrical engineer of the Royal Hanna Coal & Coke Co., but a few months later re-entered the service of the Pennsylvania R. R. as draftsman in the electrical engineering department at Altoona. In this department Mr. Bender advanced very rapidly and at the end of 1903 was made assistant to Mr. J. R. Sloan, then Electrician, Motive Power Department, Pennsylvania R. R., Lines East.

By this time the use of electricity in railroad operation had developed to such an extent that the National Electric Lamp Association, now the National Lamp Works of the General Electric Co., realized that the field was worthy of a special department, and began looking around for the right man to take charge of this work. Mr. Bender was selected as the man best qualified to fill this position, and on April 1st, 1909, he resigned from the Pennsylvania, and became Commercial Engineer of the National Lamp Association.

Only the men directly in charge of the electrical departments of the various railroads know how well Mr. Bender has co-operated with them in improving the work of their departments, not only on questions of lamps, but general carlighting and shop equipment as well.

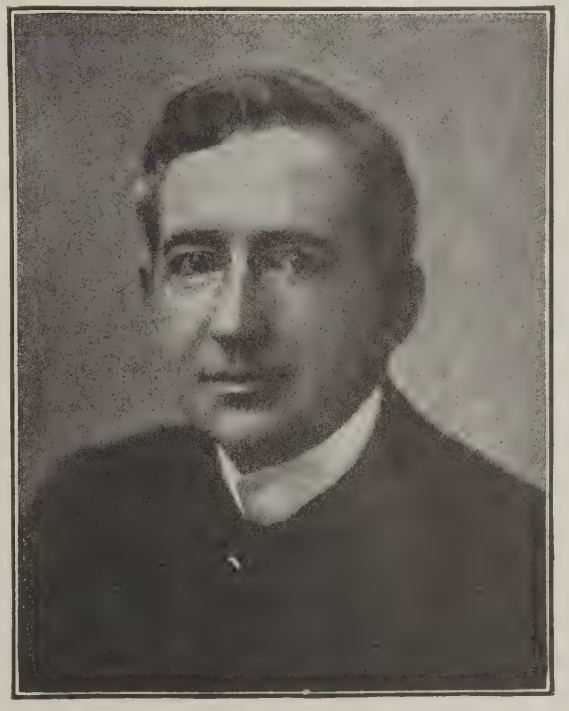
Mr. Bender has prepared a very complete and most valuable hand book on Train Lighting and, after countless hours of untiring labor on his part, this book has been brought up to date and a second edition issued last year.

On August 1st, 1913, with the formation of the Commercial Development Department of the National Lamp Works, Mr. Bender was made Manager of the department. In this capacity, however, his relations with the railroad field will not be materially altered, and his many carlighting friends will be pleased to learn of this further advancement.

He is a graduate in Mechanical and Electrical Engineering of the Scranton Correspondence Schools, and an Associate member of the American Institute of Electrical Engineering, Associate member of the Association of Railway Electrical Engineers, member Association of Iron and Steel Electrical Engineers, and member of Illuminating Engineering Society.

A. D. CURTIS.

Augustus D. Curtis, president of the National X-Ray Reflector Co., makers of the Eye Comfort (Indirect Lighting System), member of the Illuminating Engineering Society and of the Association for the Conservation of Vision and Prevention of Blindness, has been unusually honored by S. B. Kiser, the widely known writer of stories and verse. Mr. Curtis is also president of the Universal Anti-Glare Society, to which belong, by right of belief, all those who recognize the wrong and injurious practice of direct lighting units for interior illumination. From all sections of the country representatives of this society are being heard from, and laws in many states are in process of formation. Every headache or eye-ache caused by brilliant exposed lighting units makes a new member—even though he be an unconscious one. If it is possible to unite their protests, it will result in a rapid improvement of living and working conditions. Mr.



A. D. Curtis.

The Five Essentials

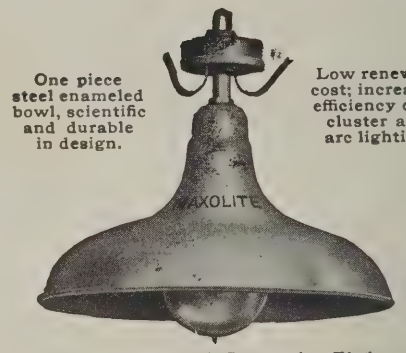
Gain 55% in Light
Save 20% in Power

The Maxolite

A One Piece Porcelain Enameled Steel Reflector

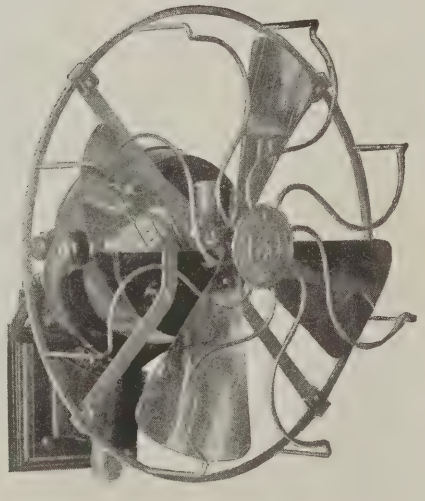
Replaces Arc Lamps for Railway Shop and Yard Lighting

WRITE FOR BULLETIN NO. 41


One piece steel enameled bowl, scientific and durable in design.
Low renewal cost; increased efficiency over cluster and arc lighting
MAXOLITE

Bowl Type With Suspension Fitting

Diehl Railway Type Fans Give the Finishing Touch to Passenger Comfort



Just the turn of a switch by the porter in his closet, starts the fans. Passengers in their chairs or seats are not interfered with. No pole is stretched above their heads nor are they disturbed by a porter climbing up in seats to control the fans.

The fan body is readily removable from the base without disturbing the wiring. The general design of both base and fan body is of a tone with the general surroundings; silent, unobtrusive, elegant.

Demand on all your orders QUALITY and HOUSE OF SERVICE, carrying the largest Prompt shipments are our specialty. If you go to you for the asking. Write for it on your

Central Elect

320-326 South Fifth Ave. ***The House***

to First Class Service

OKONITE

TRADE MARK
REG. U.S. PATENT OFFICE.

The Standard of All Insulations

Okonite insulation with its toughness, elasticity, and high electrical resistance is always placed concentrically around the conductor. The result is a product absolutely dependable.

Wire installed in railway cars should be the best. Okonite is made in one grade only—THE BEST.

D & W Non-Arching Refillable Fuses Will Save You 65% in Fuse Cost

This is due to the fact that they may be refilled at low cost. Some of their advantages: full rating on label; safe indicator—no metal exposed; extra heavy caps and tubing; ampere capacity stamped in fiber; perfect alinement of soldered blades.

SERVICE—then write us. We are THE stock of electrical supplies East or West. have NOT our big instructive catalogue, it will letterhead.

rir Company

of Service CHICAGO

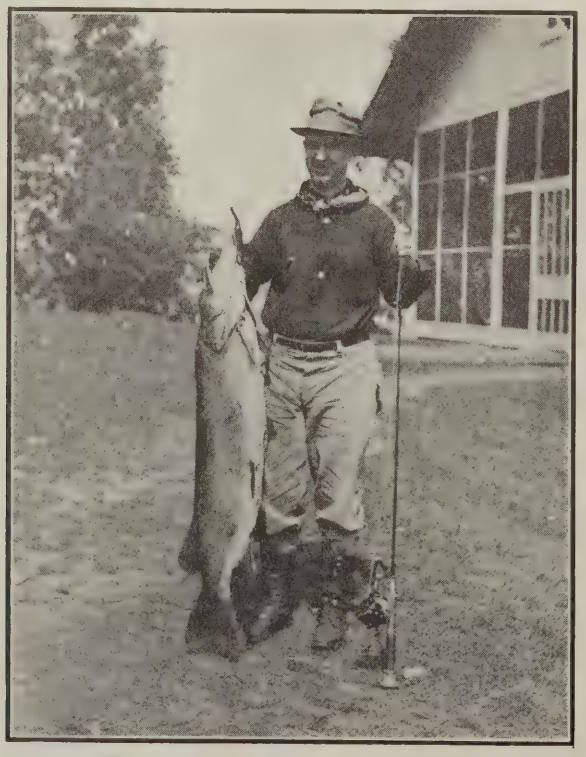
Kiser wrote the following poem and dedicated it to Mr. Curtis, after his introduction of the "Eye Comfort" lighting system:

He had a great and splendid dream
Who was the first to claim from steam
The service which it owned mankind;
And he possessed a regal mind
Who was the first to find a way
To lure the lightning from the skies:
But no less worthy than were they
Is he whose light turns night to day
And softly soothes our aching eyes.

We owe a debt to him who found
The way to reproduce the sound
Of voices that, forever still,
Will cease, some day, to sweetly thrill:
And we are deeply in their debt
Who lead from darkness into light:
Well worthy of the praise they get
Is he who has contrived to let
Our sight be guarded in the night.

We laud the artists and the seers;
Their fame is treasured through the years;
Discoverers and warriors claim
The fair rewards of lasting fame,
And in the ages yet to be
Another shall be honored, too:
He who has studied so that we
May rest our eyes, yet, resting, see,
Shall be among the worthy few.

Mr. Curtis is now on the Continent, where the Eye Comfort Lighting System is meeting with much favor, especially in England.



Thirty-four and One-half Pounds.

Secretary Andreucetti Catches Big "Muskie"

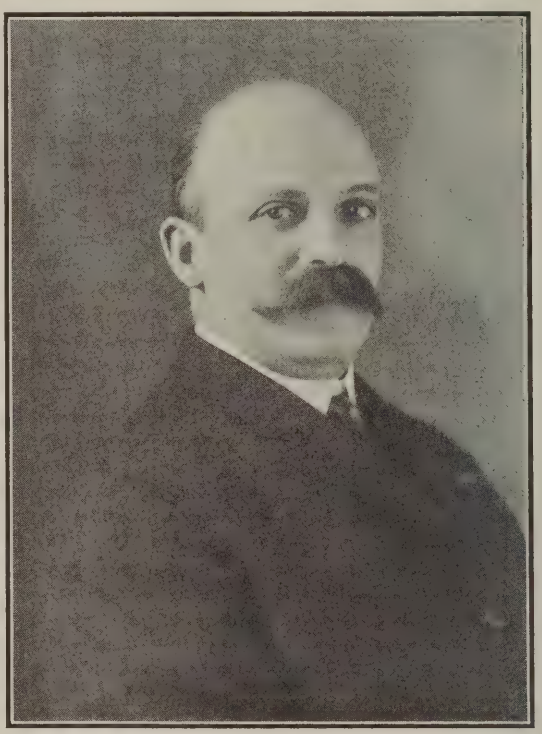
Looks as if our worthy Sec.-Treas. can do other things beside running the Association and being "watch dog" of the treasury.

"Joe" went up into the northern woods of Wisconsin in the middle of August on a two weeks' vacation and comes back with a wonderful story of adventure—looks as if he had the real thing, judging from the photograph, but anyway here's the tale:

It was a 34½ lb. muskie that measured about as long over all as Joe did. It took thirty minutes' of strenuous work to finally land him. A Skinner spoon hook, a No. 2 King Fisher line and steel rod did the trick.

WM. G. BEE.

Mr. William G. Bee, who has been connected with Thomas A. Edison for the past eleven years, has been elected Vice-President and General Sales Manager of the Edison Storage Battery Company, Orange, New Jersey. Mr. Bee entered the electric vehicle industry at its earliest commercial stage, going with Col. Pope of the Pope Manufacturing Company, afterwards the Electric Vehicle Company of Hartford, in 1897. At the opening of the



Wm. G. Bee.

Spanish War, Mr. Bee was among the first to volunteer and served as chief gunner's mate on the U. S. S. "Gloucester," J. P. Morgan's yacht Corsair. Returning to the Pope Company after the war, Mr. Bee spent a year in Mexico in its interests and was in charge of its exhibit at the Pan American Exposition.

While with the Pope Company Mr. Bee gave Mr. Edison his first ride in an electric vehicle, his first automobile experience. Since the perfection of the new Edison alkaline nickel-iron storage battery a few years ago, Mr. Bee has directed the sales policy of the company, which has already supplied one-third the storage batteries at present in electric truck service with similar remarkable advances in pleasure cars, railway train lighting, signaling, house lighting, ignition and other applications.

"Billy" Bee is one of the best known and best liked members of the electric vehicle fraternity, and his many friends in both the electric and gas fields are congratulating him on the substantial recognition of his work evidenced by his recent election.

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of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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STATEMENT OF THE OWNERSHIP AND MANAGEMENT, REQUIRED BY POSTAL AUTHORITIES, of Railway Electrical Engineer, published monthly, at Chicago, Ill., required by the Act of August 24, 1912.

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Edward Wray, Publisher.

Sworn to and subscribed before me this 25th day of September, 1913.

E. M. Holmes,
Notary Public, New York City.
(My commission expires March 31, 1914.)

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The Sixth Annual Convention.

Another year has been added to the life of our Association and it has been a year of activity, effort and advancement. Although there is no great increase in the number of members, largely due to the fact that our worthy secretary has strictly enforced the rules regarding payment of dues, the quality of membership of the Association has undoubtedly improved.

That the scope and vision of the Association has broadened as shown by a great diversity of subjects covered in the committee reports and papers presented, and the high character of these reports bears witness of earnest and conscientious work on the part of the various committees.

Probably no association in the country has greater possibilities before it than does the Association of Railway Electrical Engineers, for every year witnesses a great advancement in the application of electricity in railroad operation; so let us make sure that we measure up fully to our opportunities by extending our lines of activity so as to include all developments in the big subject of railway electrification.

Our Headlight Laws.

An interesting commentary on our editorial in last month's issue regarding the standardization of locomotive headlight specifications is found in the report of the Committee on Locomotive Headlights, published in this issue. It will be seen that there are altogether 17 different specifications embodied in the headlight laws enacted by 28 states. Our worthy legislators must at least be given credit for great originality in this matter, but for the most part these specifications give evidence of a profound ignorance on their part of the engineering features involved.

Of what use to the locomotive engineer, in preserving the lives of either those on his train or those ahead of it, is a 1,500 c. p. headlight, if that light is not properly reflected down the track where it will be of service? Or what does it mean when we define a headlight, as "10,000 c. p. measured with the reflector." Assuming the light is reflected in a parallel beam and the headlight delivering certain total light flux; if measured at 1,000 feet, it would indicate a headlight of just four times the total candlepower that it would if measured at 500 feet.

In a few cases the requirements seem to have a more logical and a practical basis, for it is specified that the headlight shall make it possible to discern a man at a certain distance off. But now the question: what kind of a man shall he be; a white man or a black one, shall he be dressed in white, gray, black or colored clothes—and above all, who is going to decide whether he can be seen or not?

At best this specification is dependent largely upon the personal equations and cannot be considered as adequate. An investigation of the subject by a proper commission, which should include many locomotive engineers, could determine what illumination is required for the average engineer to sight a man at the required distance, and this could then be expressed in foot candles illumination on a vertical transverse plane at that point.

Under the present situation, the conflicting specifications of the various states make it practically impossible for any railroad operating through several of these states to measure up fully to the letter of the headlight requirements in these states.

Surely this is a matter which should receive the attention of the federal authorities, either by regulation

of the Inter-State Commerce Commission, or by definite legislation by congress based on extensive investigation and practical tests by a special commission. A recommendation to this effect from the Association of Railway Electrical Engineers assembled in our 6th annual Convention, would be most timely.

Sixth Annual Convention of the Association of Railway Electrical Engineers

Hotel La Salle, Chicago, October 20-24

CONVENTION PROGRAMME.

TUESDAY, OCT. 21.

MORNING SESSION, 10:00 A. M.

Address of President.
Report of Secretary-Treasurer.
Unfinished Business. New Business.
Committee of Standard Reports for Operation.

AFTERNOON SESSION, 2:00 P. M.

Committee of Terminal Facilities for Handling Car Lighting Equipment.
Committee on Head End Equipment.
Committee on Electric Headlights.

WEDNESDAY, OCT. 22.

MORNING SESSION, 9:00 A. M.

Committee on Methods of Charging Storage Batteries.
Committee on Standards. Sub-Committee.
Dynamo Suspension.
Adoption of Standard Car Light'g Reports by MCB.
Lamp Specifications.
Paper on The Problem of Incandescent Lamp Testing, Preston S. Millar, L. J. Lewinson.

AFTERNOON SESSION, 2:00 P. M.

Committee on Wire and Cable Specifications.
Committee of Installation of Wiring for Electric Light and Power in Railway Buildings.
Committee on Outside Construction and Yard Lighting.

THURSDAY, OCT. 23.

MORNING SESSION, 9:00 A. M.

Committee on Illumination.
Committee on Shop Practice.

AFTERNOON SESSION, 2:00 P. M.

For members of the Railway Electric Supply Manufacturer's Association who wish to bring before the members of the A. R. E. E. any new devices or improvements in their apparatus.
Paper. Gas Electric Truck, Mr. L. C. Josephs, Jr. of General Electric Co.
Electric Truck for Handling Freight. T. V. Buckwalter.

FRIDAY, OCT. 24.

MORNING SESSION, 9:00 A. M.

Committee on Data Information and Question Box.
Report of Auditing Committee.
Election of Officers.
Adjournment.

Application for permission to present talks on new devices and improvements must be made to Sec. J. A. Andreucetti, Association Headquarters 19th Floor Hotel La Salle, before Wednesday noon, Oct. 21, 1913.

ENTERTAINMENT.

Monday, October 20

8: P. M.—Informal Reception and Dance. East Room, Mezzanine Floor. Hotel La Salle.

Tuesday, October 21

2:30 P. M.—Automobile Tour about the City, Tour will start from the Hotel La Salle at 2:30 sharp, and all the ladies holding badges are invited.

8:30 P. M.—Ladies' Night for Viewing Exhibits.

Wednesday, October 22

1:45 P. M.—Meet for Matinee Party at Garrick Theatre. William Hodge in "The Road To Happiness." All ladies holding badges are invited. Meet promptly at 1:45 P. M. in Ladies' Writing Room South of the East Entrance Hotel LaSalle.

Friday, October 24

7:00 P. M.—Fifth Annual Banquet given by the Railway Electric Supply Manufacturers' Association to the Association of Railway Electrical Engineers. Various prominent Railway Officials will be the speakers of the evening. The banquet will be followed by an informal dance.

Manufacturers Represented at the Convention.

Adams & Westlake Company.
Adams Bagnall Electric Company.
American Pulley Company.
Appleton Electric Company.
Benjamin Electric Company.
Central Electric Company.
Consolidated Ry. El. Lt. & Equip. Co.
Crouse-Hinds Company.
Cutter Electric & Manufacturing Company.
George Cutter Company.
Economy Fuse & Manufacturing Company.
Edison Storage Battery Company.
Electric Storage Battery Company.
Electrical Testing Laboratories.
General Electric Company.
Gould Coupler Company.
Hess-Bright Manufacturing Company.
Kerite Insulated Wire & Cable Company.
Wm. M. Lalor, Manufacturers' Representative.
Main Belting Company.
Moon Holophane Co.
Moon Manufacturing Company.
National Electric Lamp Association.
National X-RAY Reflector Co.
National Metal Molding Company.
Holophone Works of the G. E. Company.
Norma Company of America.
Oneida Steel Pulley Company.
Pass & Seymour, Inc.
Pyle National Electric Headlight Company.
Railway Electrical Engineer.
Remy Electric Company.
Safety Car Heating & Lighting Company.
S. K. F. Ball Bearing Company.
Thompson Electric Company.
United States Light & Heating Company.
Western Electric Company.
Westinghouse Electric & Manufacturing Company.
Westinghouse Lamp Co.
Weston Electrical Instrument Co.
Willard Storage Battery Company.

THE REPORTS OF THE COMMITTEES

The Association of Railway Electrical Engineers assumes no responsibility for the individual views of its members on the various topics and disavows any action taken on the various subjects except such action as is taken in due course and accordance with the constitution.

Report of Committee on Head End Equipment

Historical:

Your committee in presenting this report will not attempt to take up the time of a busy convention by giving you a detailed history of one of the oldest, if not the oldest, systems of electric train lighting, but will endeavor to present to you, by means of diagrams and a series of notes, the practices obtaining on the various trunk lines of this country using this system for electric train lighting, the idea being to present this information to the convention in such a way as will permit of a close comparison and analysis with a view of general improvement.

The present steam head end system with storage battery auxiliary was first taken up in this country in the late 80's and since that time each individual line has been developing its own system without any particular regard to what other lines were doing. This will be noted from the various sketches embodied in this report.

In 1912 all of the roads using the head end system in accordance with the recommendations of our Association adopted sixty-four volts as the standard, the tungsten lamp making the lower voltage practicable. The Chicago, Milwaukee & St. Paul, however, had made the initial move in this direction in 1910 when they changed the voltage of their Southwest Limited from 110 volts to 64 volts.

In 1908 the Northern Pacific Railway made some experiments with a head end axle equipment on one of its one-night runs. The machine used was 20 Kw. capacity and mounted on top of the truck on a cast steel case arching the center sills and extending into the dynamo car. Description of this apparatus will be given more in detail later.

Steam Supply:

Returning to the steam head end equipment: We will first take up the various methods in use for supplying steam to the dynamo engine from the boiler of the locomotive. The general scheme of piping on the locomotive itself is practically the same on all lines which have submitted reports, steam being taken from the turret on the boiler head through a reducing valve to the train line by means of two-inch pipe with a flexible metallic connection between the engine and tender. The supply line is generally equipped with pop valves set at a fixed pressure which varies on different lines.

The steam furnished through this pipe is also used for supplying steam for the heating of the train. The connection between the rear end of the tender and the dynamo car is made by two general types of flexible connections; one flexible metallic steam hose; the other extra heavy rubber steam hose manufactured to meet special specifications.

The piping of dynamo cars can be classified under two general heads—one which readily permits of running the dynamo car in one direction only; that is,

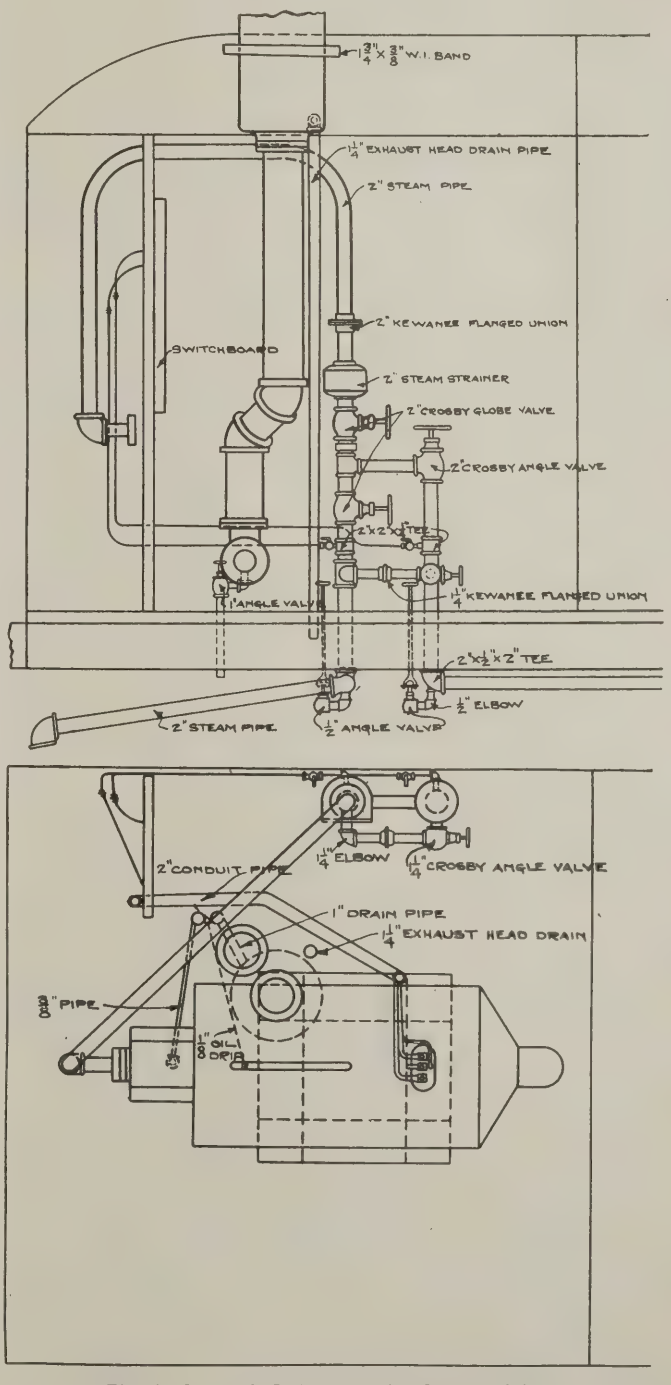


Fig. 1—C., B. & Q. Ry. Interior Steam Piping.

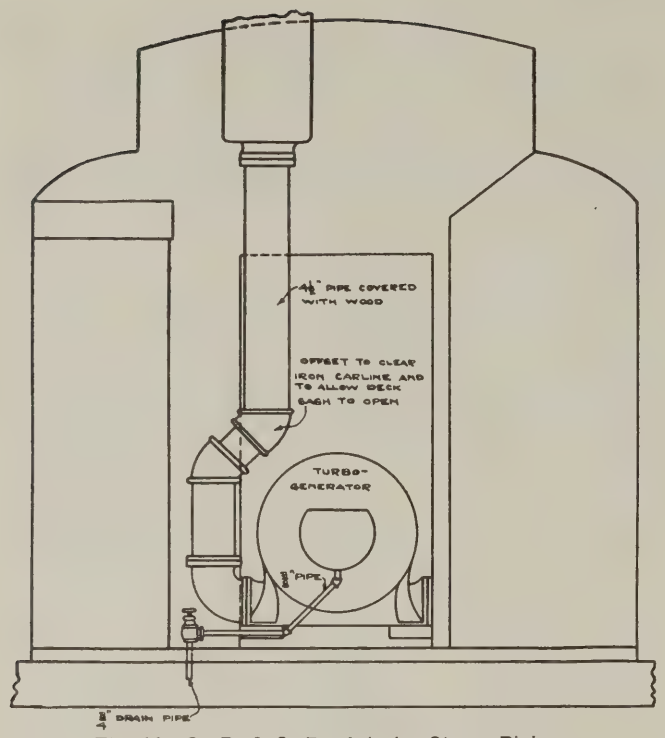

4½" PIPE COVERED WITH WOOD
OFFSET TO CLEAR IRON CARLINE AND TO ALLOW DECK SASH TO OPEN
TURBO-GENERATOR
3/4" PIPE
3/4" DRAIN PIPE

Fig. 1A—C., B. & Q. Ry. Interior Steam Piping.

with the dynamo in the head end of the car next to the engine; the other permits of running the dynamo car in either direction.

The accompanying sketches (Figures 1 to 5 inclusive) show the piping systems used on the Chicago, Burlington & Quincy, Chicago, Milwaukee & St. Paul, Great Northern, Northern Pacific, and Union Pacific Railroads.

Two good examples of piping which permit of the use of steam from either end of the car are those of the Great Northern and Union Pacific Companies. The system used by the Great Northern is perhaps to be preferred for the reason that the steam passes through the separator before going into either turbine or heating system. This is important in that it not only reduces the moisture in the steam but frees it from all dirt entering through the steam passages.

Figure 4 shows an example of the piping design for use of steam from one end of the car only. It will be noted on a casual examination of the various figures that there are as many methods of valving and piping as there are figures. Some of the designs have special merit and the adoption of meritorious features by all railroads interested deserves careful consideration.

Reducing Valves and Exhaust Heads:

Before leaving the steam piping arrangement we desire to call especial attention to the importance of providing the best possible design of pressure reducing valves and exhaust heads. The design of pressure reducing valves should be such that it will maintain an absolutely uniform pressure on the low pressure side regardless of variation on the high pressure, it of

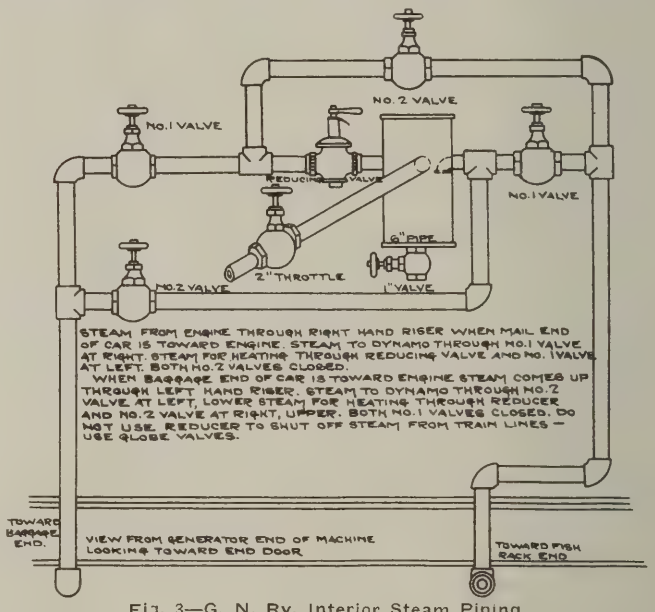

NO. 2 VALVE
NO. 1 VALVE
REDUCING VALVE
NO. 1 VALVE
6" PIPE
NO. 2 VALVE
2" THROTTLE
1" VALVE
STEAM FROM ENGINE THROUGH RIGHT HAND RISER WHEN MAIL END OF CAR IS TOWARD ENGINE. STEAM TO DYNAMO THROUGH NO. 1 VALVE AT RIGHT. STEAM FOR HEATING THROUGH REDUCING VALVE AND NO. 1 VALVE AT LEFT. BOTH NO. 2 VALVES CLOSED.
WHEN BAGGAGE END OF CAR IS TOWARD ENGINE STEAM COMES UP THROUGH LEFT HAND RISER. STEAM TO DYNAMO THROUGH NO. 2 VALVE AT LEFT, LOWER. STEAM FOR HEATING THROUGH REDUCER AND NO. 2 VALVE AT RIGHT, UPPER. BOTH NO. 1 VALVES CLOSED. DO NOT USE REDUCER TO SHUT OFF STEAM FROM TRAIN LINES — USE GLOBE VALVES.
TOWARD BAGGAGE END.
VIEW FROM GENERATOR END OF MACHINE LOOKING TOWARD END DOOR
TOWARD FISH RACK END

Fig. 3—G. N. Ry. Interior Steam Piping.

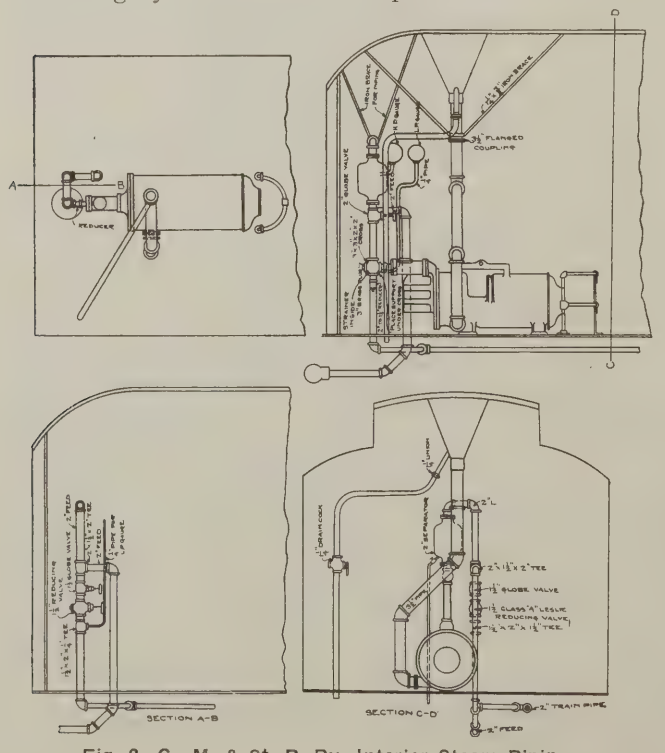


Fig. 2—C., M. & St. P. Ry. Interior Steam Piping.

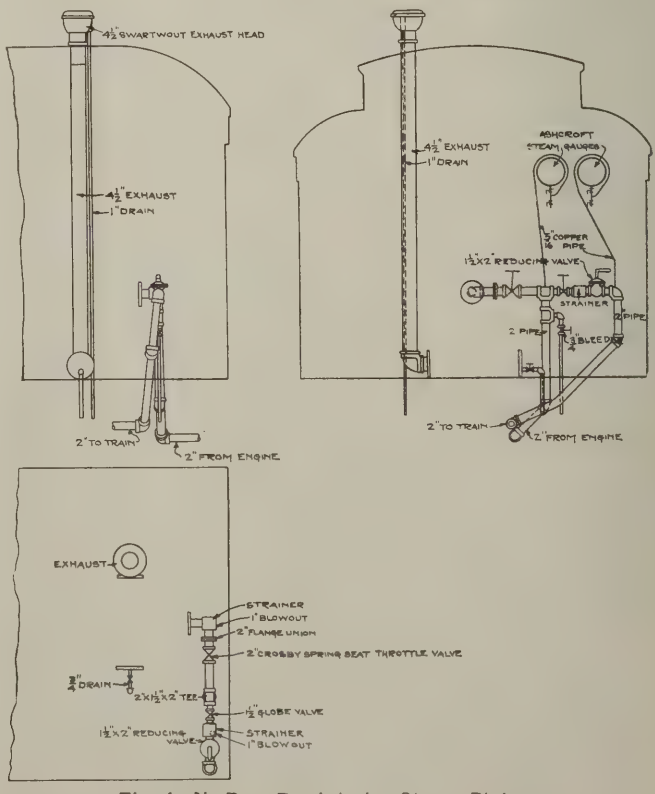


Fig. 4—N. Pac. Ry. Interior Steam Piping.

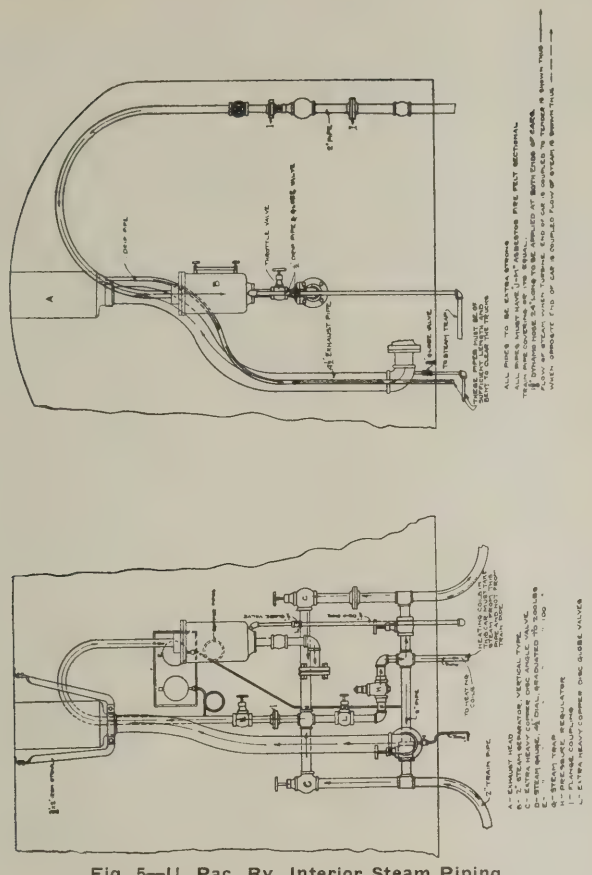


Fig. 5—U. Pac. Ry. Interior Steam Piping.

course being assumed that the high pressure will always be greater than that required for operating the lighting outfit or heating the train. The design of the exhaust head should be such that the back pressure is reduced to a minimum and that the maximum amount of water and oil is taken from the exhaust steam and drained to the under side of the car rather than over the roof. The latter is of particular importance in cold climates.

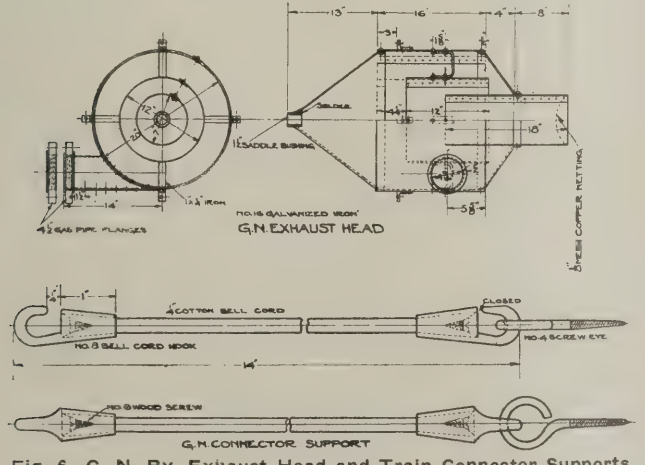


Fig. 6—G. N. Ry. Exhaust Head and Train Connector Supports.

The design and material entering into valves should also be seriously considered. There is too much of a tendency to purchase valves on price only, little or no consideration being given to the design or material. All material entering into valve parts should be new and not scrap material used in cheaper grades of valves. A very good mixture in use by one of the lines is as follows:

Copper	86%
Tin	8%
Zinc	3%
Lead	3%

Flexible Hose:

The following is a brief outline of the situation as regards the use of flexible metallic and rubber hose between locomotive tender and dynamo car:

The Baltimore & Ohio is using Greenlaw metallic hose, rubber hose proving unsatisfactory. The results obtained from the Greenlaw are reported as being fairly good but their maintenance has been heavy, due principally to couplers striking the roadbed either when accidentally unlocked or when they have not been hung up after being disconnected. Failures from these causes cannot justly be laid to the metallic hose.

The Chicago, Burlington & Quincy Railroad also use the Greenlaw hose. They have a great many in service and are obtaining very satisfactory results; maintenance being much cheaper than with heavy rubber steam hose formerly used.

The Chicago, Milwaukee & St. Paul are using heavy steam hose with satisfactory results.

The Chicago & North Western are using armored steam hose with satisfactory results, although some of their officials closely associated with train lighting work prefer metallic hose similar to the Greenlaw.

The Great Northern use extra heavy rubber steam hose with standard one and one-half inch couplers, with satisfactory results. This hose is used for several weeks on high pressure, closely inspected, and when deterioration is apparent which renders the hose unfit for high pressure, it is moved to the rear of the train and used in steam heating service. They have tried several types of metallic couplers, including the Greenlaw, but with unsatisfactory results on account of loss and leakage.

The Northern Pacific also use a heavy rubber hose, it being 1⅝ inches inside diameter, 8-ply hose, and is purchased to specification. They are also experimenting with the Greenlaw joints with satisfactory results.

The Union Pacific use a six-ply rubber hose with a Chicago type 302 connection, with fair results. They are also experimenting with flexible hose but have not as yet adopted any standard.

It is the opinion of the majority of your committee that a metallic hose with a positive connection lock will give the most satisfactory and economical results when properly installed and maintained. It is absolutely necessary that the metallic hose installation be correct in every detail, including the location of the train line piping, location and angle of elbows, length of nipples in the hose, and a proper selection of heads and locks, and, further, that when the installation is made, that the discipline be such that the hose are properly maintained and that they are hung up when not in use. A thorough analysis and investigation of the metallic steam hose situation on one of the lines developed the fact that failure of metallic steam hose was almost entirely due to the faulty installation and improper selection of parts.

Charging Storage Batteries.

There are three general methods of charging the auxiliary storage batteries used with steam driven head end systems. One is to charge en route, another is to charge while cars are laying over at terminals, and the third is a combination of the two.

Two methods of charging en route are used; one to charge during the period of lightest lamp load; the other to charge during the daylight hours when the lighting is ordinarily cut off. Charging en route when the lighting load is a minimum is self-evidently the best and most economical method, due to the material saving in steam, higher efficiency of the generating

plant and less liability of burning out fans which may be required, and lamps burning in dark portions of the train during the charging period. Charging en route during the lighting hours necessitates some provision to reduce the voltage at the lamps, eighty volts nominal being carried on the car mains connected to the dynamo terminals for charging. From reports received this is accomplished in four ways:

First: Batteries and lamps are placed on two separate circuits. All loops in the train back of the dynamo car are opened. Batteries are connected di-

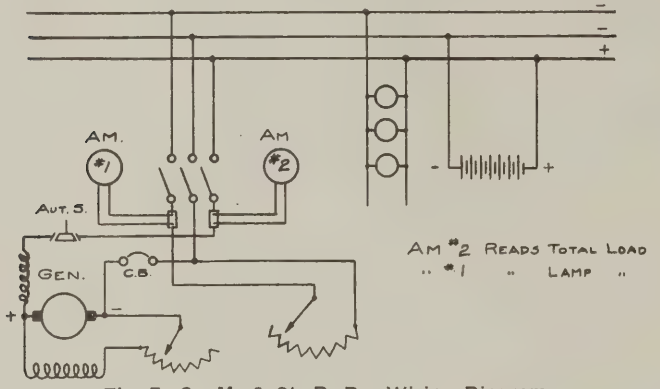


Fig. 7—C., M. & St. P. Ry. Wiring Diagram.

rect to the dynamo mains, the lamps to the positive dynamo main and the third wire. The lamp circuit receives current from the dynamo mains through a variable resistance placed in the loop in the dynamo car, the lamps being connected on the two outside wires of the three-wire system. This method is used by the Chicago, Milwaukee & St. Paul and by the Great Northern; and has recently been adopted by the Northern Pacific. (See figures 7, 8 and 9.) With this system the Chicago, Milwaukee & St. Paul finds very little terminal charging necessary. The Great Northern do absolutely no terminal charging. The switchboard wiring for the latest Northern Pacific system will be similar to the system used by the Chi-

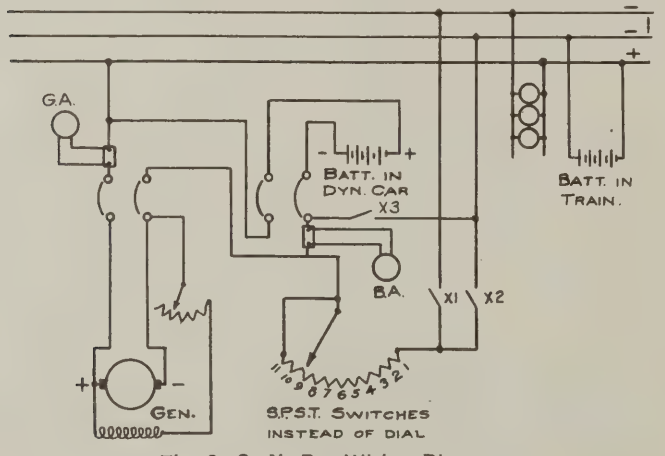


Fig. 8—G. N. Ry. Wiring Diagram.

cago, Milwaukee & St. Paul, with the exception that no automatic switch will be used and the lamp circuit rheostat will have twelve instead of five stages.

The switch board panel will be top connected, electrically and mechanically, so as to permit its being swung out from the wall when repairs are necessary. The resistance will permit maintaining a lamp voltage between 60 and 64 with a variation in the lamp load from 16 to 200 amperes.

The lamp resistance should be so proportioned that batteries may be fully charged while maintaining a normal lamp voltage. It is not ordinarily necessary to provide current capacity in resistance to take care of the maximum lamp load, as the combined lamp and charging current would probably exceed the generator's normal rated capacity. A lamp load of 100 amperes maximum in most cases will not be exceeded.

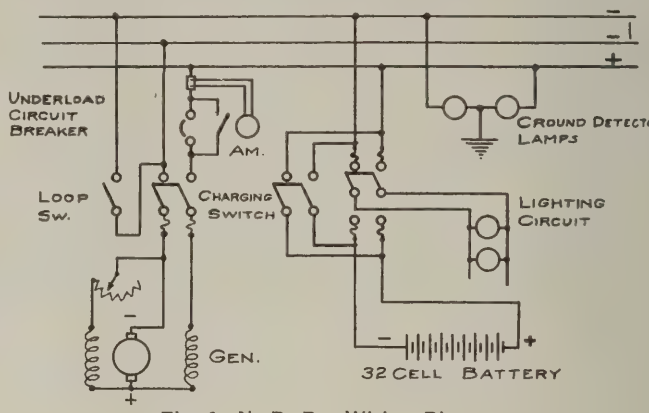


Fig. 9—N. P. Ry. Wiring Diagram.

It will be noted that with this system it is possible to maintain the equal potential train line or the divided train line system with a common positive. On some roads it is the practice to use the equal potential train line as long as the lamp load exceeds 100 amperes and to charge batteries on the divided train line system when the lamp load is less than 100 amperes.

Second: Batteries cut into two equal parts and charged in parallel by taking current from the 64-volt train line through a variable resistance. This

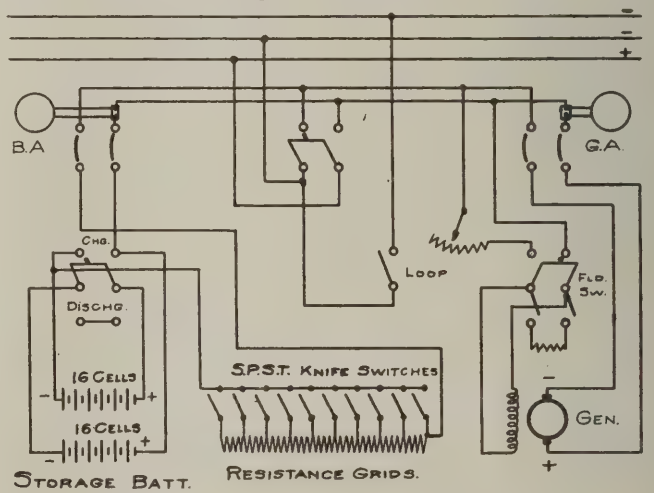


Fig. 10—C. & N. W. Ry. Wiring Diagram.

method is used by the Chicago & North Western. (See Figure 10.) Terminal charging by this road has been discontinued.

Third: The use of a lamp regulator on every car which maintains constant voltage on lamp circuit with variable voltage on battery circuit. This method is standard on the Baltimore & Ohio Railroad. (See Figure 11.) Terminal charging on this road is eliminated as far as possible, though it is required regularly on certain cars which operate in head end trains for a short part of their runs and occasionally for batteries when turbine failures on the preceding trips occur.

Fourth: No special wiring provisions are necessary for charging batteries during non-lighting hours only or at terminals. This method is standard on the Union Pacific and until recently on the Northern Pacific. The Union Pacific, however, advise that they

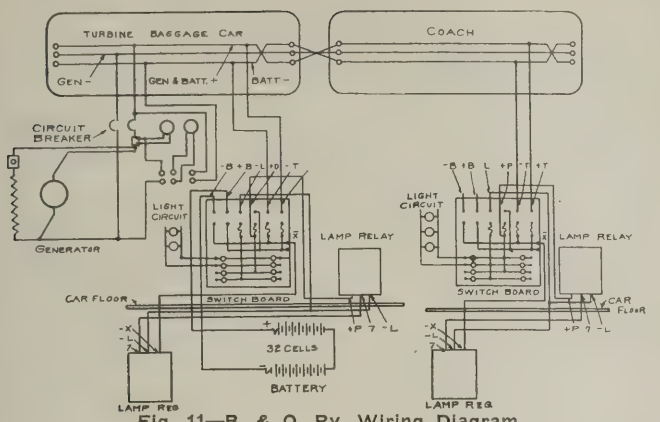


Fig. 11—B. & O. Ry. Wiring Diagram.

do not find terminal charging necessary except in emergency cases.

Rules for Operating Electric Train Lighting and Steam Heat Apparatus.

The following is an outline of the practices followed by the various railroads as regard the operation of train lighting and steam heat apparatus by enginemen, train electricians, baggagemen, messengers, and trainmen:

Baltimore & Ohio.

The head end train lighting system is operated by special electrician carried on each train. This train electrician, when on duty, also controls the steam heat apparatus, but is under the jurisdiction of the train conductor. No general instructions are issued to train electricians in regard to handling the steam heat, but from time to time bulletin notices on the subject are issued by the Chief Electrician.

Chicago, Burlington & Quincy.

This road formerly employed train electricians but for the last three years have had baggagemen or messengers operate the lighting apparatus. In general, these men have nothing to do with the steam heat, except to turn off the supply when approaching a division point where locomotives are changed or at a terminal station. The regulation of the steam heat is entirely in the hands of chair car and Pullman porters. No special instructions are issued to baggagemen or messengers.

Chicago & Northwestern.

Baggagemen are trained to operate train lighting and steam heat equipment. No general instructions are issued in regard to turning on and off of steam heat except at points where locomotives are changed. In this case instructions are simply to signal the engineer to shut off the steam before reaching such a point. Instructions are positive that the steam supply must be turned off in time to allow steam to be entirely exhausted from heating system before steam connections are broken. In general the regulation of the steam heat is in charge of the train conductor and baggagemen.

Chicago, Milwaukee & St. Paul.

Baggagemen are trained to operate the train lighting and steam heat system. A book of rules and instructions governing the operation of steam heat is issued to all concerned.

Great Northern.

The head end train lighting equipment is operated by baggagemen and messengers who also handle the steam heat apparatus in the dynamo car. A book of rules covering the operation of steam heat, gas, and electric lighting, fire extinguishers, etc., is issued to all concerned. Special instructions are also issued to baggagemen relative to operation of electric light and steam heat equipment from time to time in bulletin form and posted on a special bulletin board in each dynamo car.

Northern Pacific.

Electric lighting and steam heat equipment on overland trains in charge of train electricians. Equipment on local or short runs is in charge of express messengers. Special rules and regulations governing the handling of steam for operating the train lighting dynamos and for heating of passenger train cars are issued to all concerned. Special instructions are issued to train electricians from time to time in the form of bulletins. These bulletins are placed on the bulletin board at terminal yards.

Union Pacific.

Baggagemen handle electric train lighting and steam heat apparatus. No special instructions are used but several paragraphs in the general book of rules cover the handling of steam heat.

The companies mentioned using special instructions will doubtless be glad to furnish same to anyone interested upon request.

Maintenance of Equipment.

The following is a brief outline of methods used by various railroads in maintenance of their head end equipment:

Baltimore & Ohio.

Train electricians look after minor repairs and general inspection of dynamo equipment en route, reporting to car foremen at terminal points defects which cannot be remedied en route. Running repairs are made by forces under the jurisdiction of the car foremen at terminal points. Heavy repairs requiring shopping of cars are made in the electrical repair shop.

Chicago, Burlington & Quincy.

A machinist is employed at various important terminals who co-operates with terminal electricians in care of equipment. Dynamo equipment receives thorough overhauling when cars go through shops for general repairs.

Chicago & Northwestern.

Maintenance of train lighting equipment taken care of by regular maintenace force at California Avenue Coach Yards, Chicago. Dynamo equipment receives a thorough overhauling when cars are shopped for general repairs.

Great Northern.

Dynamo equipment is kept in repair by special machinist at St. Paul assigned to this work, which requires about one-third of his time. Running repairs to electrical equipment are made by terminal electricians. Heavy repairs are made in electrical repair shops.

Northern Pacific.

Minor repairs enroute are taken care of by train electricians. Light running repairs are made by terminal electricians; heavy repairs at main shops. Equipment receives a general overhauling when cars are shopped.

Train Connectors.

The following is an outline of practices followed in connection with train connectors by various lines:

Baltimore & Ohio.

Use the Gibbs 3-G connectors. Male connector heads are connected by three 46-inch lengths of No. 00 extra flexible cable to special specifications, reading as follows:

"Jumper cables to be No. 2/0 B. & S. rubber cov-

ered single blade extra flexible. Each cable to consist of a sufficient number of tinned copper wires of size not larger than No. 28 B. & S., to give not less than 133,593 actual circular mils (sum of all the wires), insulated for 600 volts, with 30% Para rubber, insulation 5/64 of an inch thick, covered with single weather proof braid."

The cables are held in clear position by a special rubber band, supported by a hook located above the vestibule opening.

Reports from the B. & O. indicate that this method of supporting train connector cables has not proven entirely satisfactory and that complaints are not infrequent from passengers on account of their coming in contact with the cables.

CHICAGO, BURLINGTON & QUINCY.

Use Gibbs 3-G connectors. Male connector heads joined by No. 00 cables 30 inches long, each consisting of 833 strands of No. 28 wire. Connectors are supported in clear position by rubber rings which hook in the top of vestibule door opening.

CHICAGO, MILWAUKEE & ST. PAUL.

Use Gibbs 3-G type of connector with male heads manufactured by the Loeffelholz Company, Milwaukee. This head is simply an old style Gibbs male connector with an improved method of connecting the cables. The connection is made by a wedge clamp tightened by a nut which also acts as a sleeve for the cable. Officers from this road state that the use of this type of head has reduced breakage of cables 80 per cent. Cables are supported in clear position by a leather strap fastened to a hook which slides on a rod fastened to the top of the vestibule opening.

CHICAGO & NORTH WESTERN.

Use Delta Star Gibbs 3-G type connector. Male connector cables are held in clear position by a rubber ring suspended by a hook over vestibule opening.

GREAT NORTHERN.

Use Gibbs 3-G type connector. Male connector heads are joined by three 41-inch lengths of flexible cables. Cables are held in clear position by a 12-inch length of one-fourth inch braided cotton bell cord with a No. 8 bell cord hook at each end. One of the hooks is closed over a No. 4 screw eye screwed into the vestibule finish one inch to the left of the center line of the car and one inch above the bottom of the finish. (See Figure 6.)

Head End Axle System.

The Northern Pacific Railway has been experimenting for a number of years with various types of large capacity axle driven generators for lighting an entire train. In March, 1909, a test was made of an axle-driven, 20-Kw., 80-volt generator installed in a special dynamo car. This machine was mounted on a steel sub-base bolted to the car truck and arching the center sills. The drive was by means of two leather belts running over idler shafts between the car axle pulleys and the generator pulleys. The wiring arrangement was for constant voltage. Control of the voltage and current was by means of Bliss automatic regulator. One large set of storage batteries on the dynamo car only was used for the entire train.

This equipment was run for several trips on one of their short runs with very good electrical results. Owing to operating and other conditions existing at that time the use of this type of equipment was temporarily discontinued. In the fall of 1912 three trains running between St. Paul and Winnipeg were each equipped with a 4-Kw., 50-ampere, 80-volt "Safety" axle-driven generator outfit. The machines are belt driven and are mounted on the car trucks with standard link suspensions.

Each train consists of a parlor car, dining car, two coaches, and a mail and express car, the four passenger cars only being lighted by electricity. The generator is located under the dining car. The parlor car and both coaches are equipped with nine plate, 200 ampere hour storage batteries. All cars are equipped

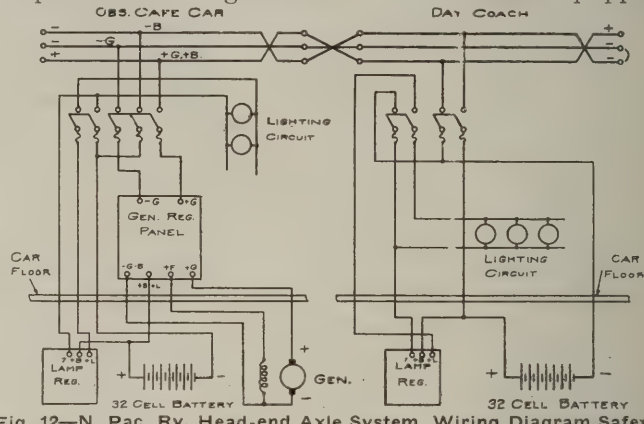


Fig. 12—N. Pac. Ry. Head-end Axle System, Wiring Diagram Safety Equipment.

with lamp regulators and are connected to each other in the usual manner by standard train connectors. The total lamp and fan load is 50.5 amperes. The wiring is shown on Figure 12. Figure 13 shows some curves taken on the first round trip of one of these trains which may be of interest.

When the test run was made the train carried three sets of batteries above described. Later, on recommendation of manufacturers, another set was added as an experiment, it being the opinion of the electrical men of the Northern Pacific that the additional battery would not give results. This proved to be the case and the fourth set was removed. Conditions again became normal. It is very probable that two sets of batteries will maintain the lighting requirements and test to determine this will be made as soon as cold weather sets in.

By referring to Figure 13 it will be noted that the

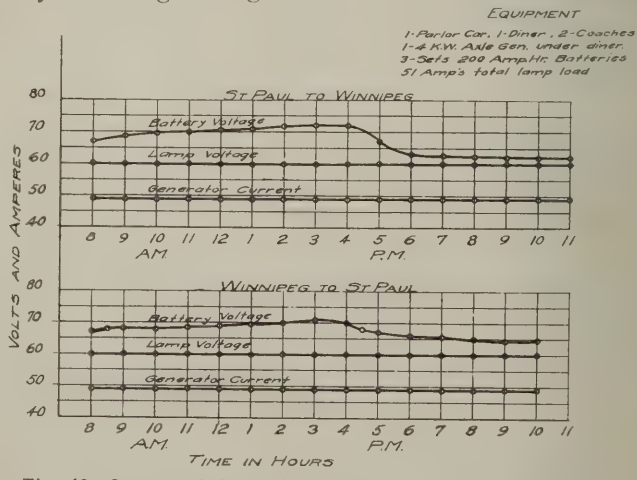


Fig. 13—Curves of Operation of Head-end Axle Equipment. Safety System.

battery voltage reached a maximum of only 72 volts before the lights were turned on. It will be of interest to know that about two weeks later the maximum had reached 80 volts at this point, showing the equipment was of ample capacity.

The operation of this equipment has been entirely successful with the exception of the usual amount of belt trouble experienced during winter months. A

five-inch, five-ply, Balata belt was originally used, but was found to be too narrow and all equipments have since been equipped with six-inch, four-ply belts, which are giving much better results.

Other points of interest in regard to the operation of this equipment are as follows:

Generator cuts in at a speed of about eighteen miles per hour.

All lamp regulators are set for 60 volts and the maximum variation from this voltage while running is approximately 1.7 per cent.

The potential coil in the machine regulator is set for a maximum generator voltage of 80.

The current coil in the machine regulator was originally set for a constant current of 49 amperes, but adjustment has since been increased to 54 amperes.

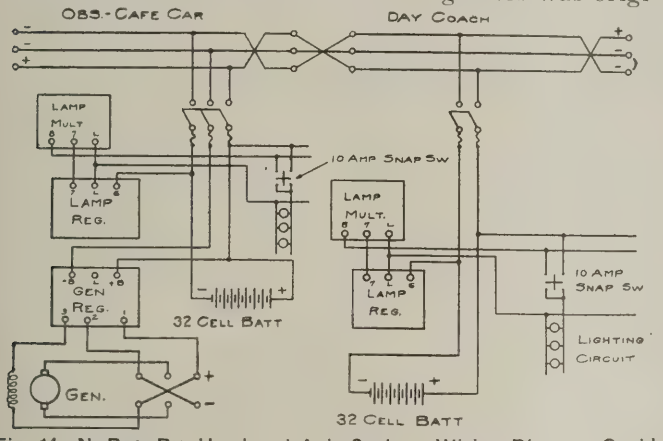


Fig. 14—N. Pac. Ry. Head-end Axle System, Wiring Diagram Gould Equipment.

In the spring of the present year seven Gould Simplex 4-Kw., 50-ampere, 80-volt equipments were installed on as many trains running between Seattle and Moclips, Wash., and between Centralia and South Bend, Wash. The cars in each of these trains which are lighted by electricity, are a parlor or cafe observation car, a day coach, and a smoker. The equipment on the various cars is as follows:

Lamp regulators and battery boxes wired complete under all cars; batteries under observation car and day coaches only; axle generator under observation car. Batteries are of the nine plate, 200 ampere hour type. The total lamp load is 37 amperes. Generator cuts in at a speed of approximately 12 miles an hour. All lamp regulators are set for 60 volts. Maximum variation from this voltage while running is approximately two and one-half per cent. The potential coil in the machine regulator is set for a maximum generator voltage of 80 volts. Current coil in generator regulator is set for a constant current of 50 amperes. The wiring diagram of this installation is shown on Figure 14.

The operation of this equipment has also proven extremely satisfactory under adverse conditions. The trains running between South Bend and Centralia make twenty-five stops in 57 miles and run very slow over five miles of heavy up-grade. Each round trip comprises a daylight and a night run.

In general, the system of lighting several cars from one generator is a success. It has been said that the batteries would soon deteriorate due to charging in parallel. This is the usual method, however, used in regular head end systems and also at terminals and it has been the experience thus far on the Northern Pacific that this method of charging leads to no unfavorable conditions. The main trouble experienced has been with belt slippage and in educating trainmen to keep train connectors up, particularly when extra cars are put in the train. The belt trouble has practically been eliminated by the use of wide belts. The education of trainmen is simply a matter of time.

The one principal objection to the system, that is, that all cars lighted must be equipped with lamp regulators, can be overcome by the use of a single large capacity lamp regulator located in the generator car. With this method any car wired for electric lights may be used in the train. A lamp regulator of this type will be used in connection with a 20-Kw., 80-volt axle equipment, which is nearly ready for delivery. This machine will be located inside the baggage car and mounted directly on the truck in the same manner as the one previously referred to, except that the drive will be by means of Morse silent chains. Instead of being a constant current machine as the smaller capacity equipments are, it will be constant poten-

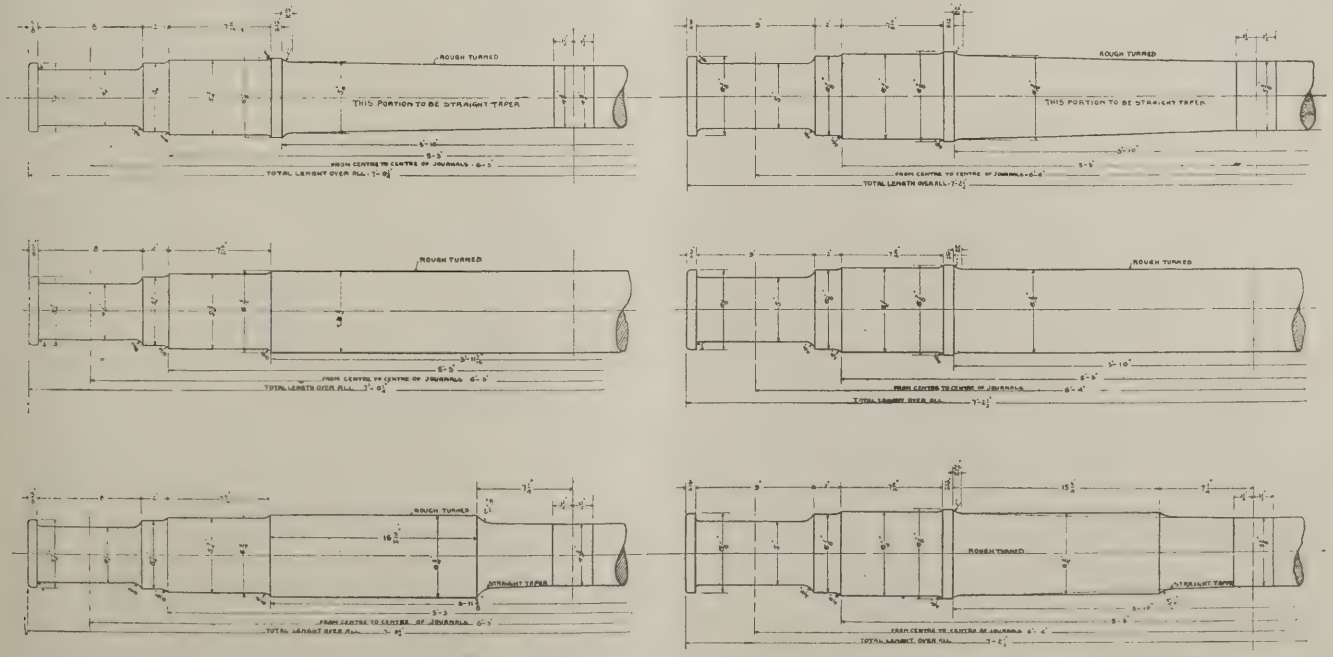


EXHIBIT "A"

Exhibit A. (See Report on Page 153.)

tial and will be protected by an overload circuit breaker located in the dynamo mains. Tests of this apparatus are awaited with a great deal of interest.

The feeling of the men operating this type of train lighting equipment can probably be understood from a reply to an inquiry regarding the results obtained, reading as follows: "I have been down on the line once since you left and everything is working O. K. I also inquire every day or two about the lighting on these trains and train crews say lighting is the best they ever saw on a train."

This quotation is not made in the spirit of boasting, but simply to indicate what can be done with axle light apparatus.

Conclusion:

It is the belief of your committee that, owing to the numerous methods of wiring and installing head end systems in dynamo cars, all concerned would profit if a standard system were adopted, and we recommend that this report be submitted to the committee on standards and that they be requested to submit their recommendations at a future meeting as to what should be adopted as standard.

Respectfully submitted,

W. J. Bohan, Chairman, Mech. Engr., N. P. Ry.
C. R. Gilman, Ch. Elec., C., M. & St. P. Ry.
Jos. A. Andreucetti, Gen. Frm., C. & N. W. Ry.
E. A. Humphrey, Asst. Elec. Engr., G. N. Ry.

Report of Committee on Dynamo Suspensions

Your committee has worked in conjunction with the members of the Committee on Standards who have taken up the matter of dynamo suspensions in connection with Train Lighting Committee of the M. C. B.

We feel that on all suspensions the metal carrying the weight of the dynamo should not be subjected to wear and where a link type of suspension is used we refer to exhibit "B" of the Committee on Standards as a typical link type suspension covering this feature.

We desire to call attention to the supension used on the Pennsylvania Railroad which is built out from the end of the truck and which is strong and safe.

The largest steel truck manufacturers have also just brought out a cast steel rigid suspension which is being applied on some cars on one of the largest Eastern railroads, this suspension having a base on which any type of standard generator may be mounted. They have also brought out a bracket which is riveted to the side of the truck, which takes the place of the side iron and brace and to which the links of any of the standard makes of suspension can be fitted.

One railroad is now experimenting with attaching the generator securely to fish belly girder and driving same by three-fourth inch flexible belt made of No. 12 steel wire formed by winding this wire on a rod spirally with the turns touching each other in normal position.

Twenty-one inch V shaped deep grooved pulley is used on the axle and eleven inch V shaped deep grooved pulley on the generator.

Flexible wire belt will stretch and allow for side movement of the truck or stones, etc., that may be picked up.

Respectfully submitted,

E. W. Jansen, Chairman,
C. J. Causland,
F. R. Frost,
N. E. Lemmon.

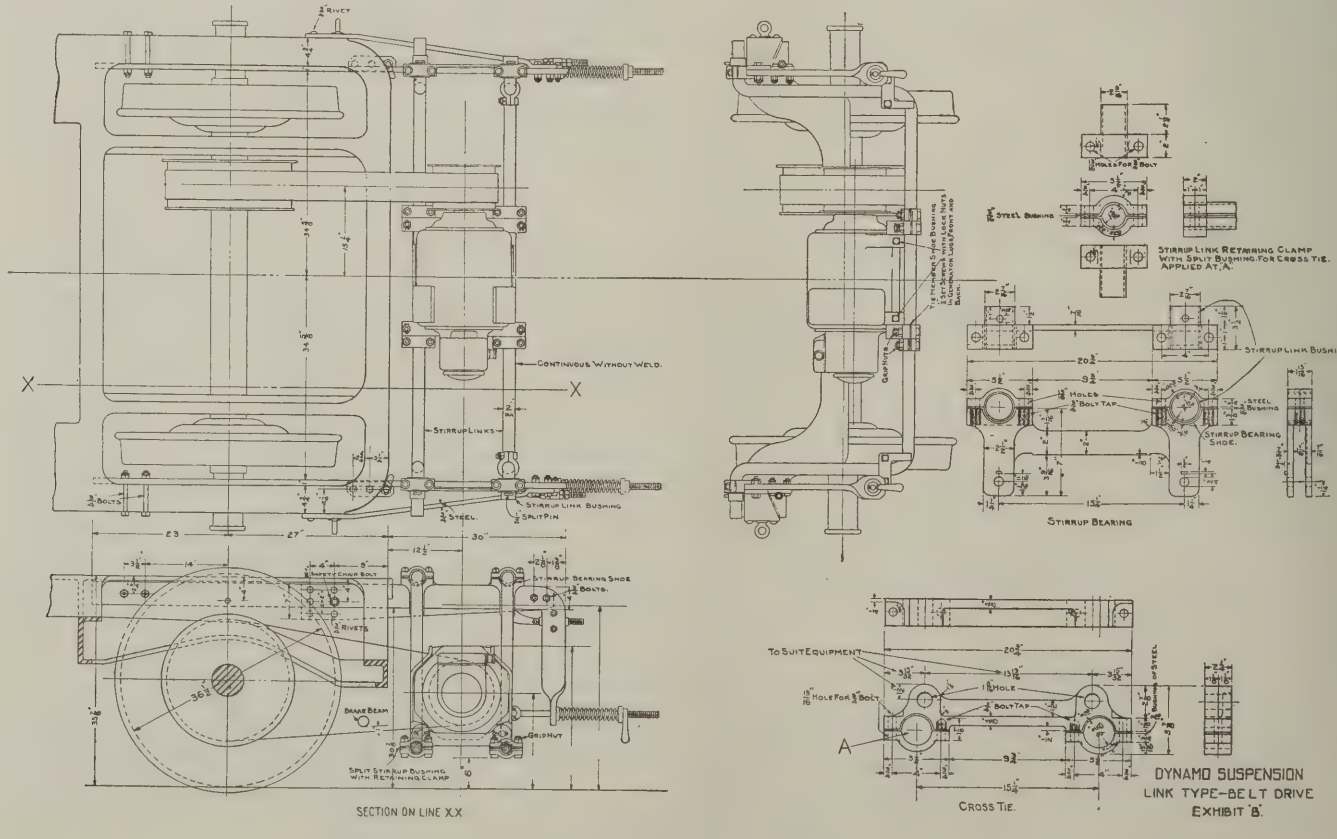


Exhibit B.

Report of Committee on Standards

This committee has worked in conjunction with the Train Lighting Committee of the M. C. B. and circular of inquiry was issued to various railroads from which about thirty replies were received and we desire to make the following suggestions for recommended practice.

Axles for Axle Dynamos.

1. Axles for application of axle pulleys should be in accordance with dimensions shown on Exhibit "A," Page 51.

NOTE—Your committee feels that the question of design of axles should be left to the mechanical men of the individual railroads in question.

You will note that on Exhibit "A" is shown three designs:

First, axle in accordance with M. C. B. standard, rough-turned.

Second, axle straight between the wheel-fit collars, rough-turned.

Third, axle with straight pulley fit.

In any of the above designs the axle pulley as recommended in paragraph eighteen of recommended practice can be applied with the proper bushing.

Standard Design of Axle Dynamo Suspension.

2. Axle dynamo suspensions must be designed so that with full diameter wheels and truck on straight, level track, any part of the dynamo or suspension must have a clearance not less than six inches above top of rail, and a clearance of at least three and one-half inches between any part of the mechanism attached to the car body.

3. In axle dynamo suspensions the metal carrying the weight of the dynamo must not be subjected to wear.

4. In axle dynamo suspensions, if side arms are used, the end to be secured to the truck frame must extend under transom and be bolted to the side frame near the transom, and if carried through or over end sill, must be held securely to end by a hooked bolt not less than ¾ inch in diameter.

5. When possible, the belt should go over the end sill and under the brake beam with belt clearances of at least one inch.

6. A typical design covering the above recommendations is shown on Exhibit "B," and recommended where applicable.

NOTE—On account of the variety of trucks and car designs, it is impossible for your committee to recommend a standard suspension which will meet all conditions; the committee, therefore, recommends the design shown on Exhibit "B" where applicable, and in addition have inserted the general requirements in paragraphs two, three, four and five which, if adhered to, will eliminate the most objectionable features of suspensions now in use.

Standard Design of Battery Box.

7. The inside dimension of battery boxes should be as follows:

Depth, front to back, 2 feet 4 inches.

Height in clear, not less than 21½ inches.

Length of compartment for two standard double compartment tanks or equivalent, 22⅝ inches.

Length of compartment for four standard double compartment tanks or equivalent, 3 feet 9¼ inches.

8. Battery boxes with two compartments each 22⅝ inches long, or with one compartment 3 feet 9¼ inches, must be designed to safely carry a battery weight of 1,600 pounds. Battery boxes with four compartments each 22⅝ inches long, or two compartments each 3 feet 9¼ inches long, must be designed to safely carry a battery weight of 3,200 pounds.

9. That in all battery box designs, two angle irons or straps shall extend longitudinally under the battery box in such a location that in case of a defective battery box the battery trays will be supported by the said angle irons or straps; the angle irons or straps shall be supported from the car body independent of the battery box proper and shall be of sufficient strength in all parts to safely support the battery in accordance with the weight shown in paragraph 8 and the additional

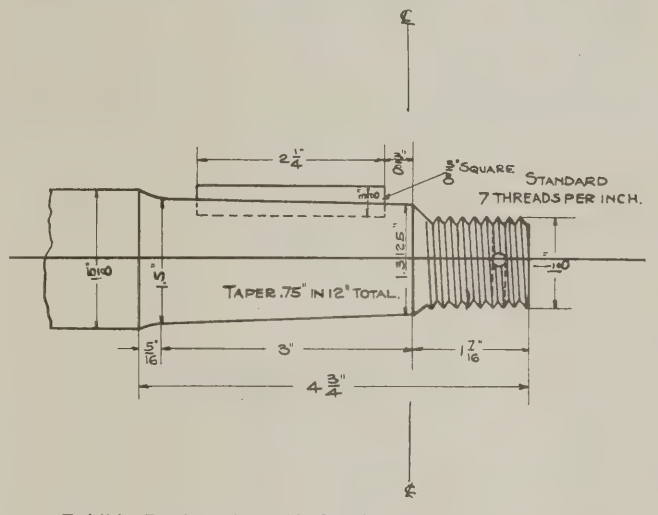


Exhibit D—Armature Shaft Fit, Proposed Standard.

weight of the battery box proper, and the angle irons or straps and the supports for same shall be so installed that they can be readily inspected for corrosion.

NOTE—On account of design of car underframing and the requirements of a different service, your committee finds it impossible to make detail specifications and dimensions for battery boxes which would be applicable for all conditions, and have therefore outlined general specifications as covered in paragraphs 7, 8 and 9, which will provide for proper strength of battery boxes and proper dimensions to allow of interchangeable equipment.

In the above you will note that on the height of battery box the minimum dimension is given instead of an exact dimension, as your committee felt that the maximum height of box obtainable should be used, but that the 21½ inch has been found to be the minimum height that can be applied on a number of roads on account of road clearances.

Recommended Practice as to Maintenance and Repairs.

10. For repairs to electric lighting equipment on cars in interchangeable or leased cars, the instructions issued by the manufacturers of the apparatus should be strictly adhered to. In the absence of any agreement, the material furnished and applied must be of the manufacturer's make.

Diameter of Axle Pulleys.

11. Diameter of axle pulleys should preferably be 17 inches or 21 inches; the diameter of generator pulley should preferably be 8 inches or 11 inches.

Electric Connector.

12. The electrical connection between the dynamo leads and permanent wiring on the car should be made with non-reversing self-locking receptacle and plug.

The committee have also gone into the matter of a standard taper fit for dynamo pulleys and show below data in regard to proposed standard generator pulley and pulley fit.

Data in Regard to Proposed Standard Generator Pulley and Pulley Fit for Electric Light Equipment on Electric Lighted Cars.

Location of center of proposed pulley relative to center of pulley as furnished by the manufacturer.

System	Type Gen.	Dia. Pulley	Location
Gould	GB	11 in.	Same.
Bliss	M4	10 in.	5/8 in. to right.
Bliss	M4	8 in.	3/16 in. to left.
Safety	F (PRR)	8 in.	3/8 in. to left.
Safety	D	9 in.	3/8 in. to right.
Safety	F	9 in.	5/16 in. to left.
U. S.	P	8 in.	3/4 in. to right.
Consol.	A	8 in.	1/2 in. to right.
Consol.	A	10½ in.	1/8 in. to left.
Consol.	D	10½ in.	Same if reversed.
Consol.	D	10½ in.	2 3/16 in. to right.
Consol.	F	10½ in.	15/8 in. to right.

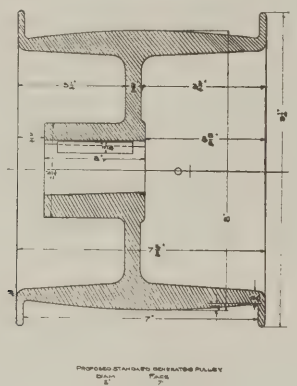


Exhibit E—Proposed Standard Generator Pulley, Diam. 8 in., Face 8 in. (not 7 in., as in sketch).

Changes to be made on proposed standard pulleys to apply same to various types of equipment, using generator pulley fit and armature shaft, as furnished by the manufacturer:

System	Type Gen.	
Gould	GB	Bore out, special bushing required.
Bliss	M4	Turn off inside of hub.
Safety	F (PRR)	Bore out, special bushing required.
Safety	D	Turn down shaft and shorten same.
Safety	F	Bore out, special bushing required.
U. S.	P	Increase key-way to 3/8 in.
Consol.	A (old)	Bushed to fit.
Consol.	A (new)	Bushed to fit.
Consol.	D	Turn down shaft and shorten same.
Consol.	F	Turn down shaft and shorten same.

If, however, the generator pulley fit on the armature shaft other than the old type Consolidated "A," is made as per proposed standard, all types of equipment will take the

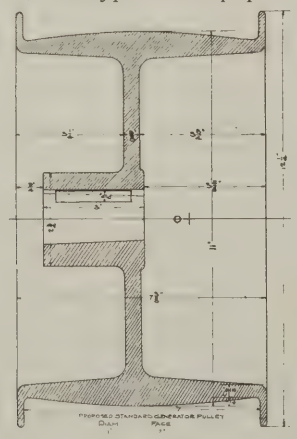


Exhibit F—Proposed Standard Generator Pulley, Diam. 11 in., Face 8 in. (not 7 in., as in sketch).

proposed standard pulley allowing ample clearance between head of generator and inside edge of pulley. The type "A" Consolidated would require a special bushing or a standard pulley with a less diameter of bore.

We also show exhibit "D" of standard armature shaft fit, exhibit "G" of standard shaft fit, exhibit "E" of seven inch diameter pulley, exhibit "F" of eleven inch dynamo pulley and exhibit "G" of eight inch axle pulley.

Exhibits D, E, F and G are presented for discussion

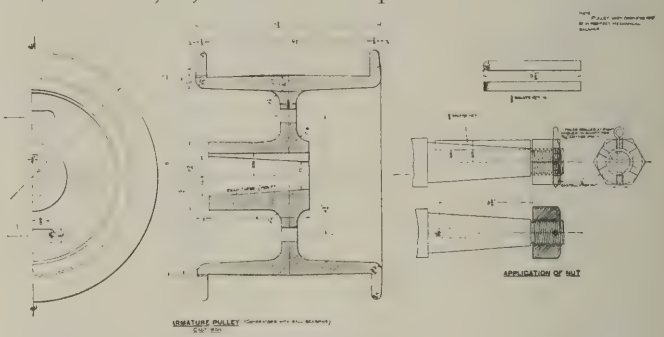


Exhibit G—Proposed Standard Generator Pulley (Cast Iron) for Generator with Ball Bearings.

as to adopting one of them for standard armature shaft fit and one for generator pulley fit.

SUB-COMMITTEE ON LAMP SPECIFICATIONS.

The Committee on Incandescent Lamp Specifications have made a canvass of the lamp situation and finds that there are three developments of considerable importance now under way which will probably require entirely new methods of inspection and test. These changes are as follows:

1—A substance known by the trade name of "getter" is being placed within the bulb of certain sizes and types of tungsten lamps. This substance tends to reduce the blackening effect in the bulb, thus permitting the maintenance of present standard life values at higher efficiencies.

2—An attempt is being made to manufacture tungsten lamps without passing current through the filament during the process of manufacture in order to keep the filament as nearly ductile as possible.

3—An attempt is being made to fill the bulb of a tungsten lamp with some inert gas under pressure. The experimental work along this line to date seems to indicate that somewhat higher efficiencies may be had by this method.

These changes are being pushed as rapidly as possible, but it is impossible at the present time to predict how soon they can be perfected and applied to lamps in commercial service or what changes in the methods of inspection and test will be necessary. We feel, therefore, that the committee is not warranted at this time recommending any changes in our specifications.

The efficiencies of the present types of tungsten lamps have changed somewhat, and these changes can be had from any of the manufacturers, so that it is not necessary to publish them in our proceedings to the exclusion of other and more important matter.

The committee, however, does recommend that in the case of railroads purchasing lamps under specifications, that the members of this Association strongly urge such railroads to adopt and use the specifications adopted by this Association.

Respectfully submitted,

E. W. Jansen, Chairman,
D. J. Cartwright,
J. L. Minick,
C. H. Quinn,
F. R. Frost,
J. H. Davis.

Committee on Standard Reports for Operation, 1913

Your committee has given the matter of standard reports a very close study and finds that as the number of electric lighted cars increase on larger roads, the handling, checking and filing of reports becomes cumbersome and inefficient mainly on account of the fact that the proper checking of these reports can only be made by a person who is thoroughly versed in the operating details of electric lighted cars as well as the mechanical and electrical details of the various equipments. Unless a system of reports that are in a measure automatically checked, is used, it becomes necessary for every electrical engineer to have a man detailed upon the checking of these reports. Therefore, your committee in recommending a car lighting trip report submits the following:

That reports be made in books substantially, but cheaply bound, containing from 100 to 150 sheets of which each alternate sheet shall be original and copy, or so arranged that an original and two or more copies may be made, if desired, depending upon how many offices will require the details of the report. These copies can either be made by having the back of the original and as many sheets as desired with carbon backs, or they

A. B. C. Ry.

Report of Changes of Batteries on Passenger Equipment Cars, including Pullman Cars, at.....Terminal, during Month of.....19

Batteries Applied.			Batteries Removed.		
Date	Initial	Set No. To	Date	Initial	Set No. From

Report below the serial numbers of all batteries on hand at Battery House at the end of the Month.

.....

.....

Batteries supplied for Special Service should be so noted.

Correct:

.....

Electrician.

may be furnished with loose carbon sheets. The carbon back copies are more convenient and insure that a clear copy is made, whereas, the loose carbon sheets will wear out and the copies will be illegible. The copies should be perforated to enable them to be easily removed, the original to be retained within the book, which shall be left in the car locker, carried in a suitable metal case. When the leaves of this book become exhausted, the book containing the original reports in date order will be returned to the electrical engineer's office as a permanent record of the equipment's performance, thus making a neat and readily accessible bound record which may be referred to with the assurance that the reports will be found in their proper relative sequence. Copies previously received may then be destroyed.

Your committee finds it very difficult to formulate a standard of reports which will meet the conditions peculiar to each and every railroad. Discussion with the heads of the electrical departments of a number of roads brings out the fact that any one form will not meet their approval in all its details. Your committee recommends the book form as outlined above for adoption and submits the following tentative forms of pages which may be added to or detracted from at the option of the user.

A. B. C. Ry.

Division.....

Report of changes in location of batteries.

Removed or Received.			Applied or Shipped.		
Date	Battery	From At	Date	Battery	To At

A. B. C. Ry.

Car Lighting Performance Report.

Car..... Train.....
Place..... Date.....
Apparatus Working.....Lights Fail.....
Sp. Gr.....Height of Acid.....
Volts Battery.....Volts Lights.....
Battery Charged.....Hours.....Amps.
Belt.....Train Conn.....Fuses.....
Lamps Missing.....
Cond. of Eq'pt on Departure.....

Cause of Failure and Action Taken.

.....

.....

.....

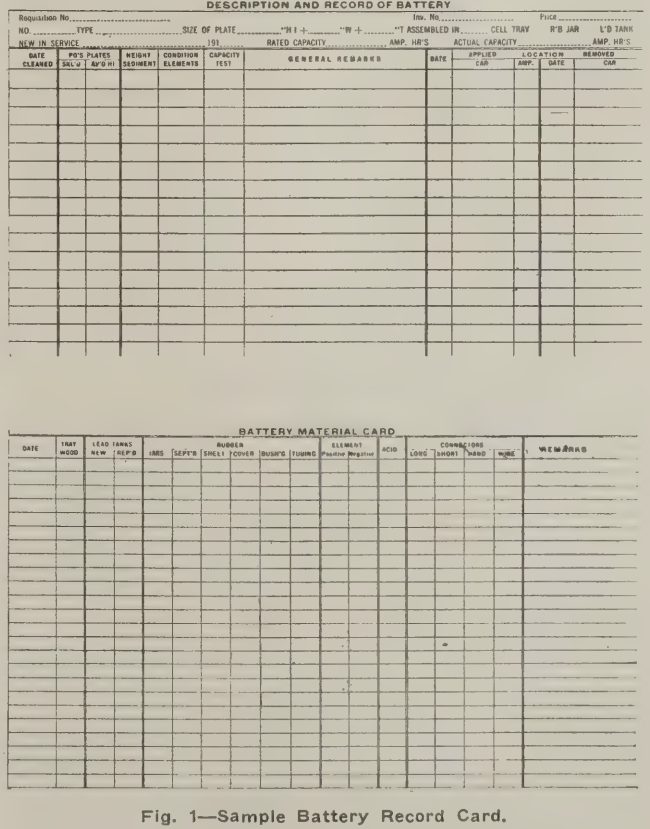
.....

Signed.....Electrician.

Mail Copy of Report to Elect. Insp.

Place Book in Locker.

The above report will work out in service as follows: Station "ONE" in reporting car "A" will make out the report, sending the copy to the electrical engineer's office and replace the book containing the original in the locker. Station "TWO" upon arrival of the car "A" will read Station "ONE'S" report, which will advise him


DESCRIPTION AND RECORD OF BATTERY

Requisition No..... Inv. No..... Price .....

NO. ..... TYPE ..... SIZE OF PLATE ..... "H I +..... "W +..... "T ASSEMBLED IN..... CELL TRAY R'B JAR L'D TANK

NEW IN SERVICE ..... 191 ..... RATED CAPACITY ..... AMP. HR'S ACTUAL CAPACITY ..... AMP. HR'S

DATE CLEANED	POS PLATES Sel'd	POS PLATES Av'd Ht.	HEIGHT SEDIMENT	CONDITION ELEMENTS	CAPACITY TEST	GENERAL REMARKS	DATE	APPLIED CAR	LOCATION AMP.	REMOVED DATE	REMOVED CAR

BATTERY MATERIAL CARD

DATE	TRAY WOOD	LEAD TANKS NEW	LEAD TANKS REP'D	RUBBER HRS	RUBBER SEP'S	RUBBER SHELL	RUBBER COVER	RUBBER BUSH'G	RUBBER TUBING	ELEMENT Positive	ELEMENT Negative	ACID	CONNECTIONS LONG	CONNECTIONS SHORT	CONNECTIONS HARD	CONNECTIONS WIRE	REMARKS

report of the conditions made by Station "TWO." In this manner Station "TWO" automatically checks Station "ONE," having before them the equipment and the report of its condition when leaving Station "ONE" and additional copies may be made that each may keep same for their record if it is desired.

It is further recommended that for keeping the costs of operation on electric lighted cars that the report of Committee on Accounts and Reports, shown on page 73 of the proceedings of 1910, be used.

F. E. Hutchison, Chairman,
Jos. A. Andreucetti,
C. J. Causland,
F. R. Frost,
E. W. Jansen,
H. C. Meloy.

Report of Committee on Methods of Charging Storage Batteries

When Used for Electric Lighting of Passenger Cars

Your committee, in investigating this subject, deemed it advisable to consider all the methods known to them of charging batteries, treating each method in detail and giving the advantages and disadvantages of each.

The subject was, therefore, divided into three parts, indicative of the service in which the battery is used, viz.:

Straight storage.
Head end.
Axle generator.

STRAIGHT STORAGE.

(a) Rate of charge and ampere hour input determined by operator based on voltage test on arrival and time available, the charging current being regulated by manipulation of rheostat.

This method of charging, while probably used to a greater extent than any other method, cannot be considered satisfactory. To obtain the best results, the following elements must all be considered and proper allowance made for each:

Make and type of battery.

Actual capacity of battery.

Physical condition of battery, with respect to sulphate, density and level of electrolyte, temperature, short circuits, condition of connections, etc.

The rate at which the battery is discharged when determining arrival voltage test and the length of time this discharge continues before making test.

The time that has elapsed between the termination of discharge in service and the time of test of voltage.

The drop in voltage in the battery connectors and in the car wiring from the terminals of the battery to the point at which the voltage test is made, due to the fact that these voltage drops will vary with the class of car on which the battery is in service.

The time available for charging.

The accuracy of the voltmeter itself and the accuracy with which it is read.

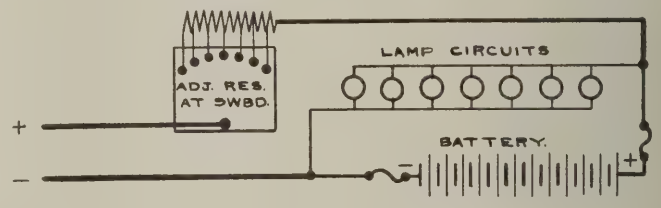
It is obvious that many of these factors are unknown quantities to the operator, and, therefore, he cannot give same proper weight. Furthermore, when there are a great number of cars to be charged, the charging rate to the battery on each car cannot be followed up sufficiently close.

At the smaller terminals betters results could probably be obtained, especially if battery voltage readings are frequently taken during the charge to determine when the voltage has reached a maximum, but the method as a whole is considered unsatisfactory.

(B) Charging current held approximately constant by manipulation of rheostat and state of charge of battery determined by constancy of voltage pilot cell, readings being taken at intervals during charge.

This method of charging is dependent upon: The accuracy with which the voltmeter is read and the assumption that the remainder of the cells are exactly similar in all respects to the pilot cell. It is essential that when obtaining the voltage readings the charging current be maintained at the same rate and that identical values be obtained with successive readings at least a half hour apart.

It is known that the assumption as made above is erroneous, but nevertheless, if properly handled, this method will undoubtedly result in prolonging the life of the battery over that obtained with the first method mentioned, but it is believed the cost of operation, on account of the amount of labor involved in holding the current constant and in obtaining the successive voltage readings, will be excessive.



Yard Charging Scheme ABC.

(C) Charging current held approximately constant by manipulation of rheostat and state of charge determined by constancy of specific gravity of electrolyte of pilot cell, readings being taken at intervals during charge.

This method of charging is dependent upon:

Class of battery.

Temperature of electrolyte, variations of which must be corrected for.

The accuracy with which the hydrometer is read and the care taken to get a representative sample and the assumption that the remainder of the cells are exactly similar in all respects to the pilot cell.

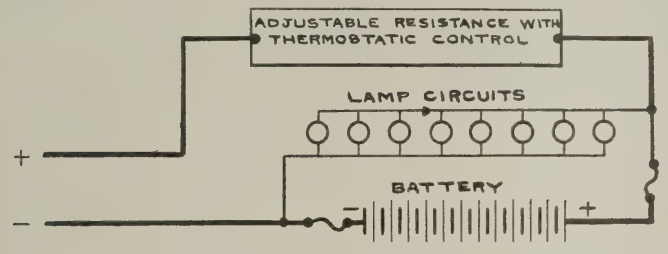
When taking the specific gravity readings it is essential that identical values be obtained with successive readings at least a half hour apart.

Like method (B) it is known that the assumption that all cells in the battery are exactly similar to the pilot cell is in error, but nevertheless, if properly handled, this method will undoubtedly cause less depreciation of a battery in a given time than method (A). However,

it is believed that the cost of operation on account of the amount of labor involved in obtaining the successive specific gravity readings would be even greater than with method (B).

(D) Charging current maintained approximately constant by automatic resistance, the resistance being controlled by a thermostat governed by the charging current.

This method of charging is satisfactory in theory (if proper means are provided for terminating the charge), inasmuch as the charging rate can be set at a value which does not tend to produce undue depreciation of

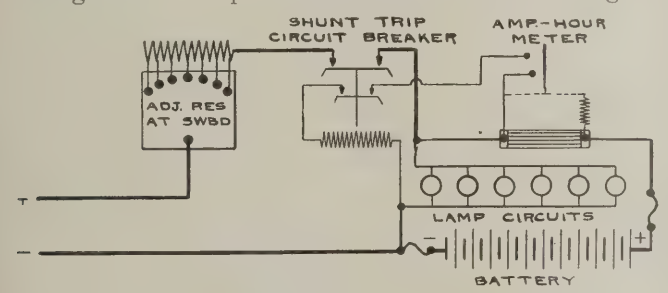


Yard Charging Scheme D.

the plates. In practice, however, it is not flexible, as in case of cars with short layovers, the rate of charge cannot be increased without adjusting the apparatus to permit higher currents. It has also been found that the thermostat is affected by weather conditions, there being considerable variation in the current flow, without any change having been made in the adjustment, according to the variation in temperature, wind velocity, etc.

(E) Charging current held approximately constant by manipulation of rheostat and ampere input determined by ampere hour meter. This meter so designed as to compensate for the ampere hour efficiency of the battery when the battery is fully charged, acting to complete a circuit through the trip coil of a circuit breaker. This breaker when opened cuts the battery off charge.

This method of charging is dependent upon the accuracy of the meter. The meter should, therefore, be checked for calibration at regular intervals. As an additional check on the meter, voltage and specific gravity readings at several pilot cells should be taken during the



Yard Charging Scheme E.

latter portion of charge so as to determine that when the meter indicates a complete charge, the battery is actually in that condition. It is believed that this method will give better results than any previously mentioned. In order that the gravity readings may be reliable, the level of the electrolyte in all cells should be adjusted previous to beginning the charge and the specific gravity of the electrolyte in all cells corrected after charge is completed, allowance being made for temperature.

(F) A definite fixed resistance is placed in series with the battery and a definite constant voltage is maintained across both battery and resistance. With this method the ampere hour input is determined by an ampere hour meter operating a circuit breaker to cut the battery off charge as in method (E).

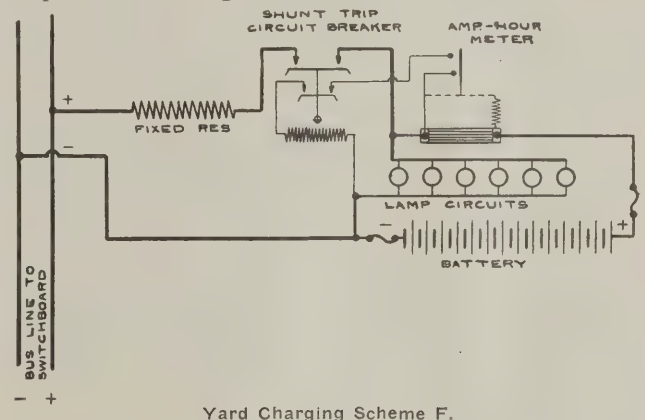
Care must be exercised in determining the proper resistance and voltage to use, and especially must the voltage be held very closely approximating the predetermined value chosen. It may be said in general that the higher the voltage chosen (which conditions the use of the greater charging resistance) the greater will be the permissible fluctuation of voltage. Increased voltage, however, increases the amount of energy consumed and reduces the amount of the "taper" effect.

It is believed by your committee that this system known as the constant potential system, is the most preferable of the various systems considered for charging batteries operated in straight storage service for the reasons that:

The minimum amount of attention is required from the operator who has only to connect the batteries to the charging plant.

The resistance and voltage being taken at such values as to permit using the highest current rate that will not injure the battery, same will be fully charged in a minimum time, while the current being reduced to normal at end of charge, excessive evolution of gas at this portion of charge is avoided, thus maintaining the efficiency of charge and minimizing the depreciation of the battery.

The elimination of overcharging the battery and so wasting power, as current is automatically cut off on completion of charge.



Yard Charging Scheme F.

The results obtained will depend upon the accuracy of the meter and the constancy of the voltage. With regard to this point the remarks under method (D) apply equally well.

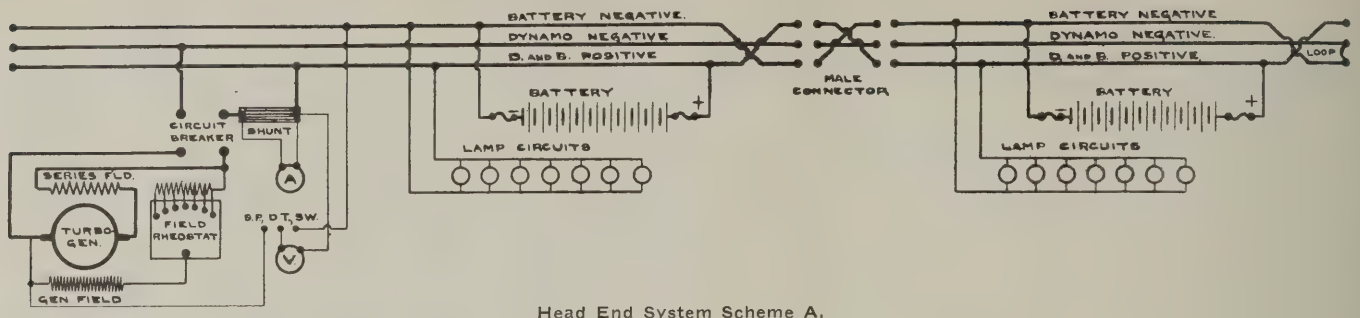
This method has the disadvantage that the rate of current flow is affected by the physical condition of the battery, i. e., whether the cells are short-circuited or sulphated by the temperature, level and specific gravity of the electrolyte, age of battery and on whether antimony and certain impurities are present in the cells.

It has the further disadvantages that for the best results it is probable that different terminal voltages and resistance will probably be required for each of the three different types of batteries, viz., Faure, Planté and Edison, although it is believed that very good results will be obtained if the initial charging rate (neglecting the first momentary rush of current) does not greatly exceed the three-hour or double normal rate and the final charging rate does not greatly exceed the normal or eight-hour rate of the Planté battery.

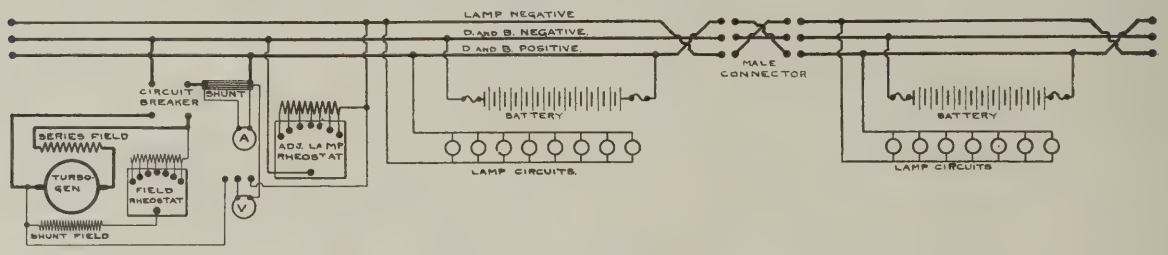
HEAD END SYSTEM.

(A) Generator voltage held at predetermined value, dependent upon number of lamps burning batteries charging or floating or discharging, as the case may be.

This method of operation is considered bad. The batteries, on the several cars, being operated in parallel, there is no information whatever to show what current



Head End System Scheme A.



Head End System Scheme B.

a battery should receive or what it does receive. The highest voltage at which the generator can be operated with any regard for the lamps is too low to permit fully charging the battery, so that it is a practical impossibility to maintain the batteries in good condition.

(B) Total charging current to all batteries controlled by manipulation of generator field, rheostat and input both of amperes and ampere hours determined by the operator, judgment being based on voltage tests. Lamp voltage controlled by main line rheostat.

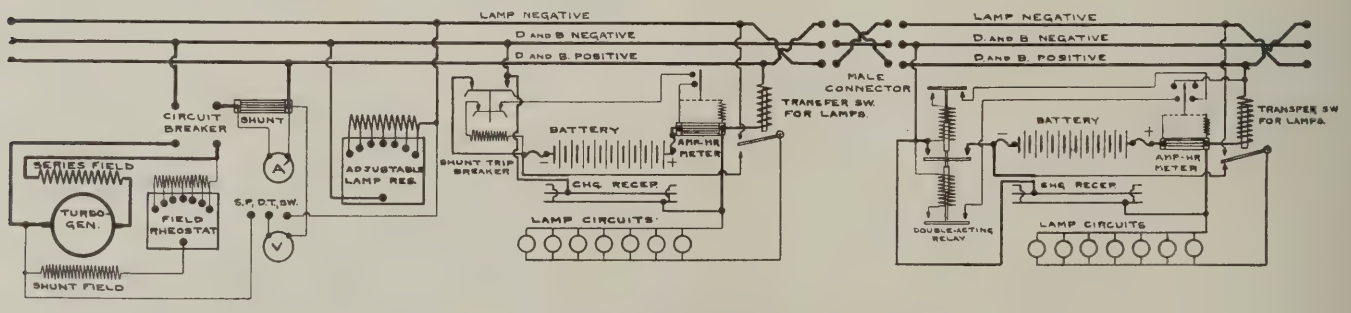
The remarks under (A), Straight Storage, apply in this case with even greater force, for the reason that the currents to the batteries on the various cars are not controlled individually, but collectively, the batteries being operated in parallel.

(C) Charging current to be controlled by manipulation of generator field and line rheostat (total current depending upon number of batteries on the line) and input to each battery determined by an ampere hour meter automatically compensating for the efficiency of the battery, and the charging current discontinued through the action of a shunt trip circuit breaker controlled by the ampere hour meter, when the charge is complete.

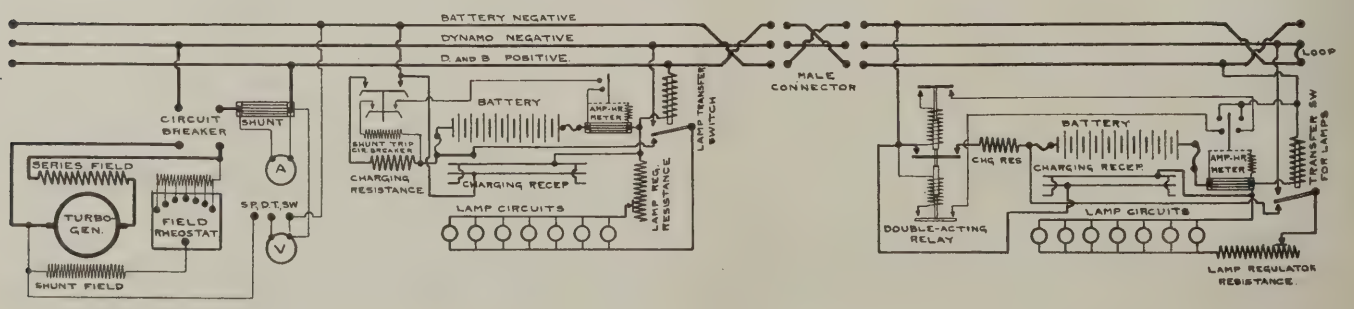
The remarks under Straight Storage (E) apply equally well here. The results obtained would probably not be as good in Head End Service as in Straight Storage, on account of the batteries being operated in parallel and the comparative physical condition of the batteries would greatly influence the actual amount of current to each battery.

It would also require close observation on the part of the attendant of the meters in each of the various cars, so that the total charging current would be reduced as the batteries are automatically cut off the charging circuit.

(D) A definite fixed resistance on each car is placed in series with the battery and a definite constant voltage is maintained across both battery and resistance. The ampere hour input is determined



Head End System Scheme C.



Head End System Scheme D.

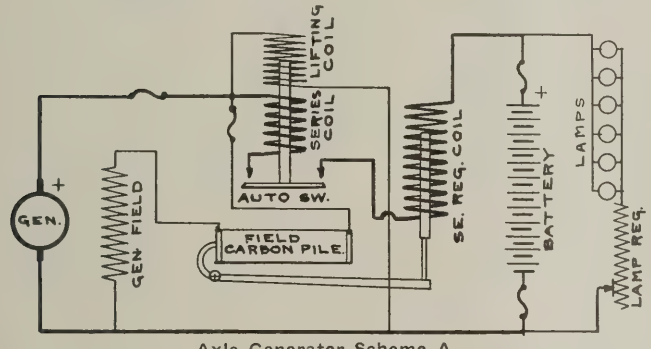
by an ampere hour meter compensated for battery ampere hour efficiency, and when the battery is fully charged opens the charging circuit by completing the circuit through the trip coil of a circuit breaker.

The remarks under (F) Straight Storage apply equally well here as do those under (C) Head End.

In actual operation of (B), (C) and (D), Head End System, it would probably be necessary to operate the batteries and lamps on separate train lines or employ lamp voltage regulators, or else carry a "floating" voltage while lights are being burned and charge the battery at such times as the lamps are not required to be burned.

AXLE GENERATOR SERVICE.

(A) Generator voltage so controlled as to maintain generator current practically constant at all times and all speeds above the "cutting-in" speed, current dividing between batteries and lamps according to demand of each.



Axle Generator Scheme A.

With this system the output of the generator must be adjusted for the class of car and "Run" in which it is operated, and the season of the year, taking account of the following:

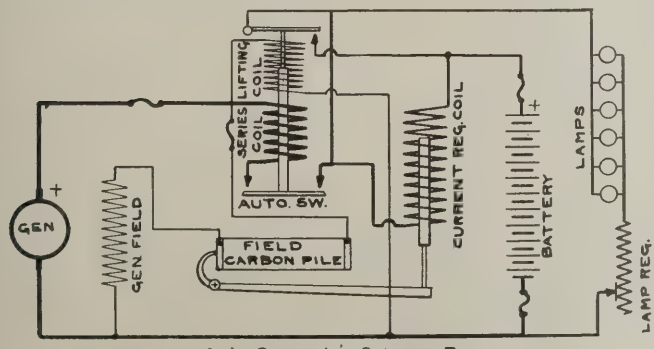
Current capacity of generators.

Ampere hour capacity of battery.

Lamp load at various times, battery charging and discharging and duration of these loads.

Experience has shown that it is not practical to make an adjustment that will take care of these variables and the result has been that batteries operated on this system are invariably over and undercharged. One very objectionable feature is the possibility of very high or very low charging rates, without regard to the needs of the battery.

(B) Generator voltage so controlled that current to battery is practically constant at all times and all speeds above the "cutting-in" speed (to do this the generator voltage increasing as the battery becomes charged) current to lamps in accordance with demands, but in addition to the battery current.

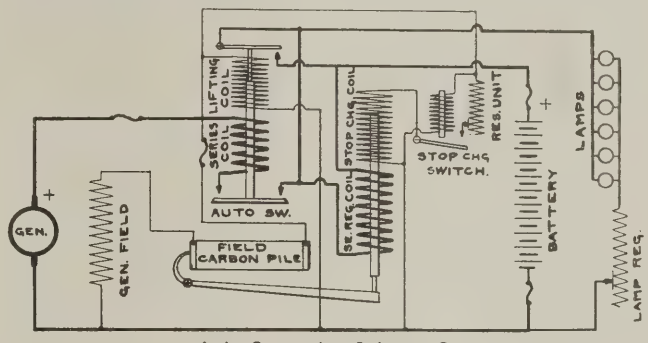


Axle Generator Scheme B.

This system is preferable to "A," Axle Generator Service, as it is possible to more nearly forecast the condition and make the adjustment to suit. It guards against low charging rates, but there is no protection against overcharging in ampere hours.

(C) Current to battery maintained practically constant at all speeds above the "cutting-in" speed until a predetermined maximum voltage is attained, after which the generator voltage is reduced and the battery "floats". The lamp load under all above conditions is carried by the generator.

The objections to this method are the difficulties of operation which naturally result when attempting to control by voltage methods a make-and-break circuit operating between comparatively narrow limits, and the liability

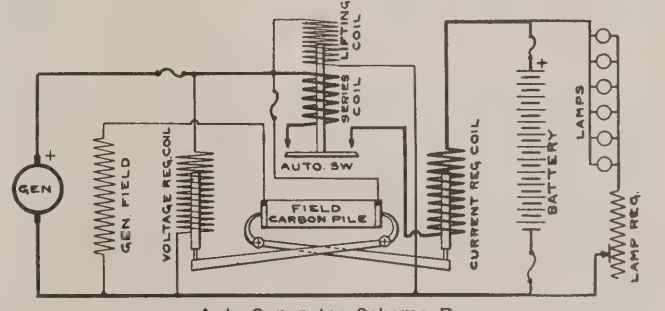


Axle Generator Scheme C.

of failure of the generator when the battery is in a discharged condition.

The battery is also required to operate through a greater number of cycles of charge and discharge, and these cycles cover a wider range than other systems, so that it is probable that the depreciation of the battery would be greater than with these other systems.

(D) The generator current is limited to a definite value and this current is maintained at all speeds above the "cutting-in" speed, the current dividing between batteries and lamps, according to the demands of each. As the battery becomes charged the generator voltage rises and when a certain predetermined maximum value is attained the generator voltage is then maintained constant, the current to the battery decreasing due to the rise of the back E. M. F. of the battery.

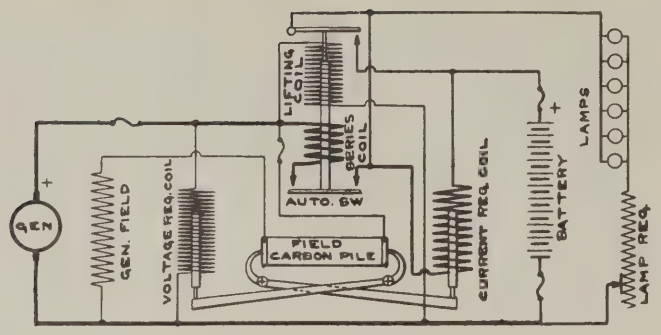


Axle Generator Scheme D.

Assuming that the maximum voltage has been properly selected, it will be seen that the battery will be protected against over-charging both in amperes and ampere hours, and also against low charging rates while in a discharged condition.

(E) The charging current is limited to a definite value, and this current is maintained at all speeds above the "cutting-in" speed, the generator supplying in addition the current required by the lamps. As the battery becomes charged the generator voltage rises and when a certain predetermined maximum value is attained the generator voltage is then maintained, the current to the battery decreasing due to the back E. M. F. of the battery.

Providing the maximum voltage attained by the generator at which the charging is terminated and "float-

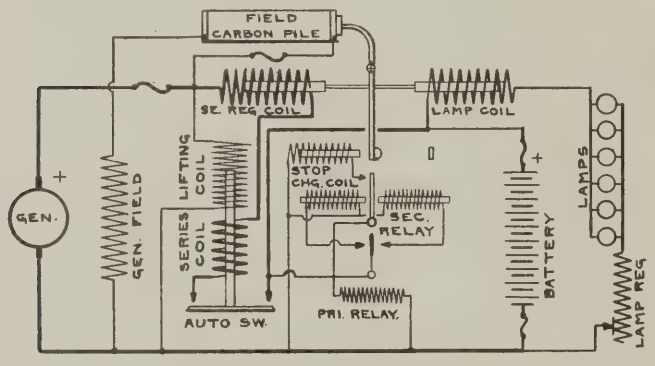


Axle Generator Scheme E.

ing" begins is properly selected, no objection can be raised as to this treatment of the battery.

(F) Generator voltage so controlled as to furnish a constant current to the batteries at all speeds above the "cutting-in" speed, and in addition to this the current required by the lamps, the generator having a rising voltage characteristic as the battery becomes charged and when the maximum voltage is attained the generator is "killed" or disconnected from the battery and the battery discharges until a predetermined low voltage is reached when the generator again begins operation.

If the capacity of the battery and generator are properly related, and the maximum voltage properly determined, this system will guard against over-charging of the battery, but with a heavy lamp load the battery will



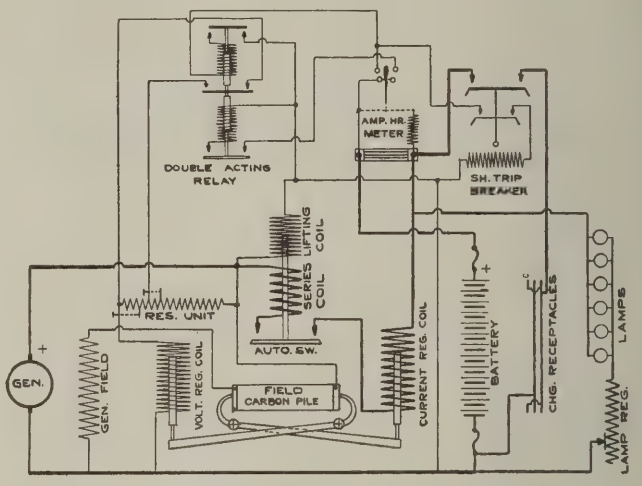
Axle Generator Scheme F.

be, at times, subject to a low charging current when more or less discharged, which is a condition that should be avoided with certain makes of batteries.

(G) The voltage of the generator is so controlled that it is held practically constant, the battery "floating", and the current dividing between batteries and lamps in accordance with demands of each.

The difficulty with this system might be the liability of the batteries to lose capacity, due to sulphate and other causes, unless provision were made to occasionally charge the battery at a higher voltage.

(H) Since the report was written a scheme has been worked out for one make of generator, whereby when the ampere hour meter shows the battery to be fully charged, the generator voltage is reduced to the "floating" battery voltage and held there until the battery has been discharged a predetermined amount, when the generator is restored to normal operating condition.



Axle Generator Scheme H.

Undoubtedly the scheme could also be applied to other makes, but the attempt to do so has not yet been made.

J. R. Sloan.

AMPERE HOUR METERS.

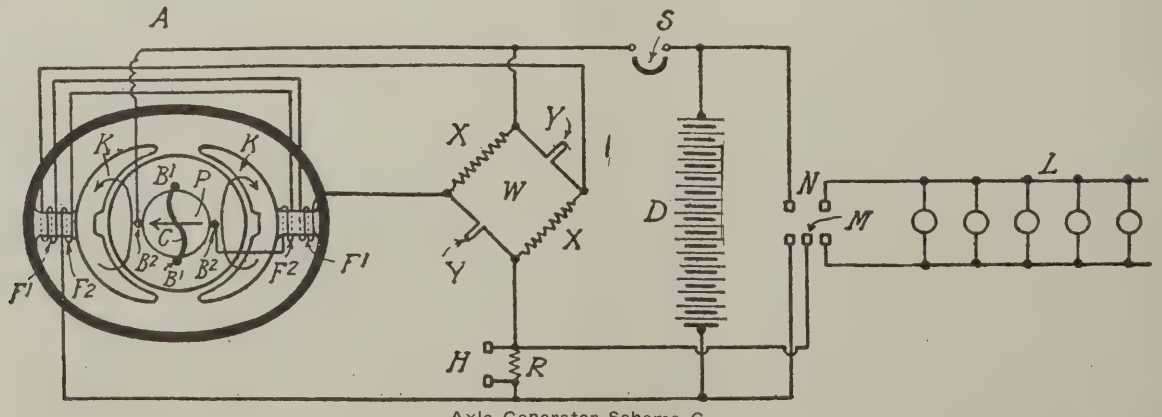
So far as your committee is aware, ampere hour meters have never been employed as a means for controlling the charging of batteries in axle generator work.

It is believed that their use as an adjunct to the regular apparatus would be extremely valuable with any of the above methods, as it would provide a check on the treatment of the battery, enabling the operator to make adjustments which would result in the best treatment of the battery within the limits set by the balance of the apparatus.

GENERAL.

In all of the above systems it must be recognized that any generator which carries the lamp load in addition to a predetermined battery load must necessarily be of a larger capacity than one that is so controlled as to give a certain definite output.

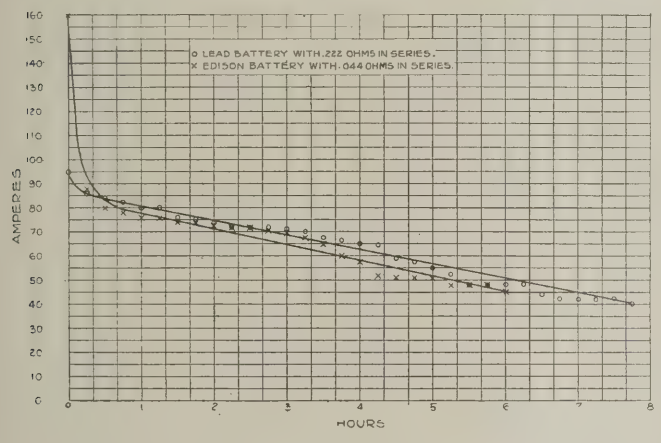
It must also be recognized that no matter how ideally the battery may be charged in theory the results obtained depend upon the reliability of the apparatus to function as called for by the theory.



Axle Generator Scheme G.

Your committee has endeavored to confine the report of the methods that are or may be employed in charging batteries without regard to the reliability of the apparatus or the accuracy with which it conforms to the theory.

Your committee desires to point out and emphasize the fact that, regardless of the theoretical merits of the systems under consideration, in order to obtain the benefit of these merits in the actual application of the system, and so reduce to a minimum the depreciation of the plates, it is essential that the batteries be maintained in good physical condition, viz.: Free from sulphate, buckled or short-circuited plates, low level or incorrect specific gravity of electrolyte, etc.



Curves of Battery Charge on Constant Potential.

The apparatus supplied for operation under any of the above systems is all designed for a battery in good condition, and the above defects will result in the apparatus treating the battery in a manner different from what was intended.

Your committee would recommend the following methods for charging batteries in the three classes of service as being, in their opinion, the most preferable:

Straight Storage—Constant potential with ballast resistance and ampere hour meters and shunt trip circuit breaker on each car.

Head End—Constant potential with ballast resistance and ampere hour meters and shunt trip circuit breakers on each car.

Axle Generator—Constant battery current with voltage control. Ampere hour meter on each car to indicate charge condition of battery and show whether terminal charging is necessary.

Respectfully submitted,

J. R. Sloan, Chairman,
F. R. Frost,
H. C. Meloy,
L. S. Billau,
W. L. Bliss,
W. E. Winship,
H. M. Beck,
H. G. Thompson,
R. C. Lanphier.

Minority Report.

"I do not quite agree with you in regard to the recommended method for charging batteries for straight storage service.

"Undoubtedly, the idea of this report is to outline the method most advisable under average service conditions found around the railroads, and should not be based on theory.

"You state in your report that in recommending the various methods, you are considering a battery which is in good condition and is normal in every respect.

"I believe that a great percentage of the batteries that are actually operated are far from normal and batteries of this class would stand a great chance of getting damaged if charged according to your recommended method for straight storage.

"I have no obejction to your recommendation theoretically; but I do believe that in practice it is liable to do more damage than good. I would, therefore, suggest that the recommendation be modified to such an extent as to recommend method F as theoretically the best method, where the voltage of the battery is normal and absolutely known. For practical purposes under general service conditions, method E should be recommended."

(Signed) R. Norberg.

Report of Committee on Illumination, Association of Railway Electrical Engineers

Your committee was instructed to investigate the arrangements, sizes, etc., of lighting units, also the relative merits of various classes of reflecting and diffusing media with reference to their application to the lighting of various classes of passenger carrying cars, and to present for recommended practice the results based thereon. Extensive data is already available on the illumination of postal cars, which is applicable to some extent to other classes of the non-passenger carrying cars.

Until the present time there has been available but little data on the subject of day coach illumination of a sufficiently reliable or adequate a character as to be of general value to the railroads. Improvement in the past has been largely by the slow and rather costly process of natural evolution as the art of illumination has progressed. The need for a comprehensive engineering research on this subject has long been felt by those who have been closely interested in improvement of the illumination of railway cars. Your Committee arranged, therefore, with the co-operation of the Lake Shore & Michigan Southern Railway and with the assistance of the manufacturing concerns directly interested in the subject, to conduct an extensive series of tests on day coach lighting. The tests were held at the Collinwood shops of the Lake Shore & Michigan Southern Railway, Cleveland, employing a modern 70-foot coach for the purpose, and lasted about eight weeks. The tests covered an investigation of the relative engineering merits of center deck and half deck system of location of units, their proper spacing, the efficiency, illumination intensity, and uniformity of all distinctive types of lighting units for both gas and electric lighting suitable for this service. It was originally the intention to study the effect of the various lighting systems upon the efficiency of the eye and the production of eye strain, as well as the minimum intensities of illumination required for continual visual work. Due to causes over which the committee had no control it was found necessary to abandon these features of the research.

Conclusions:

From the results of the day coach tests your committee has drawn the following conclusions:

(1) Equally satisfactory illumination results from the point of view of efficiency, uniformity of distribution, and absence of obectionable shadows (except where a large number of people are standing in the aisle) are obtained with either the center deck or the half deck arrangement of light units. However, on account of the

larger number of units involved, cleaning cost, reflector and lamp maintenance are materially greater with the half deck arrangement.

(2) The uniformity of distribution of illumination obtained with spacing of lighting units three seats (approximately 9 feet) apart is so poor as not to justify spacing greater than two seats (approximately 6 feet) where the best illumination results are desired. This does not apply to semi-indirect or indirect lighting where an entirely satisfactory distribution can be obtained with three seat spacing.

(3) With direct lighting systems the color of the head lining has no appreciable effect on the useful illumination produced, except where lighting units are used in which a considerable proportion of light is transmitted to the ceiling. The use of a light colored head lining, however, is recommended, as it produces a more cheerful effect in the car than where a dark color is used.

(4) The results of illumination tests show a wide range in the efficiency of the lighting units, the more efficient units producing over twice the useful illumination, compared on an equal wattage basis. Further, the various lighting units can be classified into groups each possessing distinctive characteristics. Table I shows a comparison of the groups with reference to their illumination efficiency.

(5) The illumination values obtained with electric lighting show the desirability of the use of a lamp of greater lumen capacity. Until such a lamp can be available without an increase of its wattage above the present standard train lighting lamps, the use of only the more efficient types of lighting units is recommended where the best results are desired.

Factors to be Considered in Selecting a System of Illumination.

In determining the suitability of any system of illumination for passenger carrying cars consideration should be given to the following features, which are stated in the order your committee considers, of their relative importance:

1st—Quality of illumination produced relative to permitting the eye to see with the least amount of fatigue or discomfort.
2nd—Efficiency and uniformity of distribution.
3rd—Cleaning costs.
4th—Reflector breakage costs.
5th—Artistic merit.
6th—Fixture installation and maintenance costs.

The scope of the tests covering only features coming under the second subject the others have been treated but briefly. As the report is confined almost entirely to results of the investigation, the discussion of the subject of efficiency and uniformity has been left to the last.

Quality of illumination produced.

The effect on the eye of the illumination produced by any lighting system is one of the most important factors to be taken into consideration, especially under such trying conditions as a moving railway car. It is regretted that there is so little data of conclusive character available on this subject. Bare electric lamps should never be used for general illumination in railway cars, as the high intrinsic brilliancy of the filament makes them very irritating to the eye as well as produces eye fatigue. In addition the efficiency of the bare lamp is very low, the illumination produced on planes where used by passengers with the arrangement and sizes of lamps (half deck system with 15-watt lamps) in use to a considerable extent being but slightly higher than that obtained with some of the better forms of oil lamps. Also the use of a shallow bowl type of reflector should be avoided in which the bare light source can be seen within the normal angle of vision of a passenger when standing in the aisle or sitting in a seat.

Recent tests which have been made, though not of sufficient extent to be entirely conclusive, would indicate that eye fatigue is but slightly reduced with diffuse illumination, as produced by direct lighting units of diffusing type or with semi-indirect lighting units, from that produced with the majority of types of direct lighting units employing open reflectors. The use of a lower intensity of illumination with a diffusing lighting unit of direct lighting type than that used with an open mouth reflecting type of lighting unit is not recommended unless results of further research along these lines indicate that such a reduction is justifiable.

Cleaning costs.

The relative importance attached to the question of the cleaning of lighting units varies widely among the different railroads. Little or no information is available as to the relative costs of cleaning different types of lighting units in railroad service. As might be expected, sand blasted glass, or that roughened by other means, as well as glassware having more or less corrugated surfaces require considerably more cleaning attention than a smooth surface glassware. There is also practically no reliable data on the decrease in illumination from a lighting unit in car lighting service due to its becoming dirty. Tests made along these lines in other fields of lighting indicate that this loss with certain types of units is considerable. Only as the effects of poor cleaning become more widely appreciated will there be developed high standards of cleaning practice. The obtaining of more complete data along these lines is to be desired as well as other efforts which will tend to produce better and at the same time economical methods of cleaning lighting units in car lighting service.

Reflector breakage cost.

While the breakage of glassware is very much less with electric lighting than gas lighting it may become an appreciable item with the former where expensive units are used. There is practically no information to be had of general value showing comparative costs of reflector maintenance with various types and arrangements of lighting units in car lighting service. It is to be expected that with the half deck system, where the units extend below the half deck that the reflector maintenance will be considerably greater than with the center deck system, due to breakage occurring by being accidentally hit by hand baggage when placing it in the parcel racks. There is apt to be a relatively high breakage with very thin glassware due to vibration, and at the other extreme with molded glassware over 3/16 or ¼ inch in thickness where designed for 2¼-inch holder, due to its weight.

Artistic merit.

The appearance of a car lighting unit is largely one of individual taste. Artistic merit in a lighting unit must be considered in its relation to the design and profile of the car to which it is applied both when the unit is lighted and also in daylight hours, when artificial illumination is unnecessary. There is no reason why any efficient lighting unit can not be clothed with a fixture giving pleasing lines and artistic proportions without seriously affecting its illuminating efficiency. It can therefore be stated that with any efficient lighting unit, a competent designer can produce a complete fixture pleasing to the eye and mechanically easy to install and operate.

Efficiency and uniformity of distribution.

While this is a factor of considerable importance and its effect on car lighting maintenance costs is only becoming fully appreciated its discussion does not come within the scope of this report.

Efficiency and uniformity of distribution.

As it is necessary to express more or less of the test results in technical language, the following definitions of the fundamental units are given for the benefit of those unfamiliar with these terms:

The words "candle power" is the term used to express the intensity, or pressure, of light emanating in any given direction from a light source. It corresponds, for instance, to steam pressure in steam engineering and voltage in electrical engineering.

The word "lumen" is the term used to express the quantity of light emanating from a light source. It is analagous to terms horsepower and watts used in steam and electrical engineering. It is also defined as the quantity of light which is emitted in a unit solid angle per unit of time. The unit solid angle is that which intercepts unit area on the surface of the sphere of unit radius. A uniform source of one candle unit emits 4π lumens. Therefore, the total lumens emitted by any lamp source can be obtained by multiplying its mean spherical candle power by 12.57 (4π). The rated lumens as given by the lamp manufacturers of the 15-watt G-18½ train lighting bulb is 119 and of the 50-watt G-30 bulb 397 lumens. To express values in round numbers 120 lumens for the 15-watt lamp and 400 lumens for the 50-watt lamp have been used in the test data and all results reduced to this basis, being expressed usually as so many lumens per running foot of car. To ascertain the illumination obtained using other sizes of lamps with any given type and arrangement of units it is necessary only to obtain the generated lumens per foot of car under the new conditions by dividing the total lumens in the passenger compartment of the car by the length of that compartment. The illumination produced will vary directly as the ratio of the new value of the lumens per foot to the lumens per foot of car as given

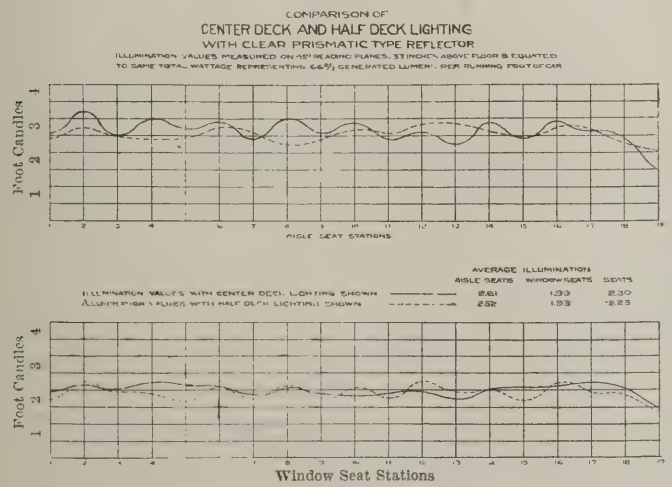


Fig. 1—Center Deck and Half Deck Lighting with Clear Prismatic Reflector.

in the test results. By expressing the test results in terms of lumens in place of watts there is eliminated the factor of lamp efficiency which varies from time to time with the improvement of lamp manufacture, thus making the data independent of any changes that may take place in lamp efficiency.

The words "foot candle" is the term used to express the illumination produced on any given surface or plane, one foot candle being the illumination produced on a surface one foot distant from a source of one candle power when the ray from that source falls upon the surface perpendicularly. As light varies with the square of the distance the number of foot candles produced on any surface varies directly with the candle power of the light source and inversely as the square of the distance from that source when the light rays strike the surface perpendicularly.

Test Car and Test Methods.

The coach employed in the tests was a standard Lake Shore & Michigan Southern 70-foot steel underframe car, finished in light mahogany, with medium olive color head lining, and dark olive green seats; the upper deck

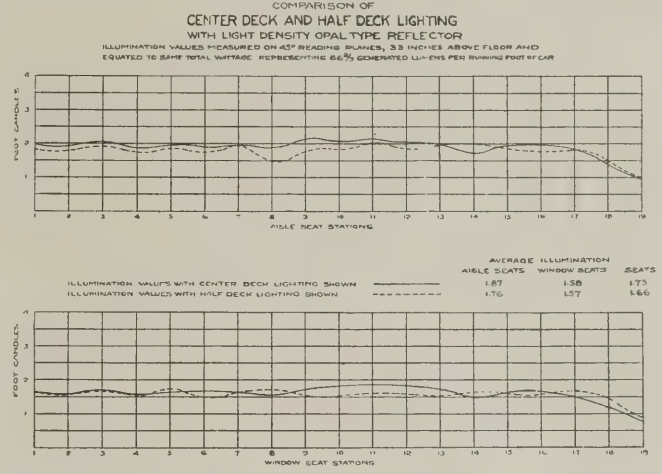

COMPARISON OF
CENTER DECK AND HALF DECK LIGHTING
WITH LIGHT DENSITY OPAL TYPE REFLECTOR
FOOT CANDLES
AISLE SEAT STATIONS
AVERAGE ILLUMINATION
AISLE SEATS WINDOW SEATS SEATS
ILLUMINATION VALUES WITH CENTER DECK LIGHTING SHOWN 1.87 1.58 1.73
ILLUMINATION VALUES WITH HALF DECK LIGHTING SHOWN 1.76 1.37 1.66
FOOT CANDLES
WINDOW SEAT STATIONS

Fig. 2—Center Deck and Half Deck Lighting with Light Density Opal Reflector.

construction being of Empire or standard New York Central design. Special attention is called to the planes on which the illumination measurements were taken. It has become generally accepted practice in comparing different systems of lighting to measure the illumination on a horizontal plane at a height above the floor corresponding to that of a typical desk or table. In these tests your committee felt that the investigation of the illumination produced at the points where it would be used most frequently by the passengers was of greater importance than the comparison of the different lighting units as determined by measurements on a more or less arbitrary plane. Illumination was therefore measured on 45-degree planes 33 inches above the floor and directly above the front edge of the seat cushions, as representing most closely the average position in which reading matter is held by the passengers. Readings were also taken on the usual horizontal reference plane 33 inches above the floor, to provide data for those who wish to compare the results of this investigation with other coach lighting tests, as well as to establish the ratio of the illumination produced on the two sets of planes with the different types of units. (For the horizontal plane readings the test stations were located 2¼ inches back from the front edge of the seats as indicated on the plans showing location of test stations.)

Test Results.

The results of the investigation can be classified as follows:

(a) Tests to determine best location and spacing of light units.

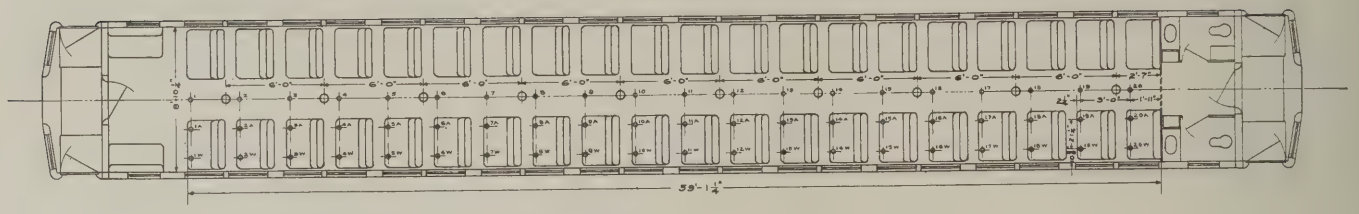
(b) Tests to determine illumination efficiency and uniformity of various types of lighting units.

(c) Tests to determine effect of changing color of head lining.

(a) Location of Light Units.

There are two arrangements of location of light units in general use for coach lighting, the center deck system

PLAN NO. 1
LOCATION OF LAMPS AND TEST STATIONS
CENTER DECK LIGHTING - TWO SEAT SPACING



o LOCATION OF ILLUMINATION TEST STATIONS
O LOCATION OF LAMPS

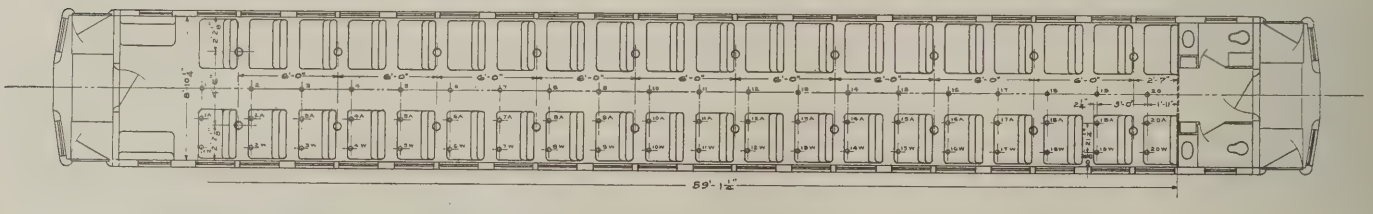
Fig. 3—Location of Lamps and Test Stations and Center Deck Lighting—Two Seat Spacing.

in which the lighting units are located on center line of the car on the upper deck, and the half deck system in which the lighting units are located over the seats, being supported either beneath the half deck by pendant fixtures or along the side of the deck by bracket fixtures. Comparison of the illumination obtained on the 45-degree reading planes with the two arrangements of locating the units, and with the use of clear prismatic reflectors, is shown in Figure 1. Figure 2 shows the results obtained with the use of light density opal reflectors. Figures 3 and 4 show the location of the lighting units as employed in these tests. A number of tests were made with various types of light units, similar comparative results being obtained. The center deck system was

It can therefore be stated that as far as efficiency and uniformity of distribution of the illumination produced is concerned there is practically no difference between the center deck and the half deck systems of locating the light units. The half deck system, however, involves the installation of at least twice as many units as the center deck system, thus materially increasing cleaning costs, reflector and lamp maintenance.

Two-seat and three-seat spacing. Center deck lighting. With the size of electric lamps in general use for train lighting service it is almost universal practice where the center deck system is used in coach lighting to employ a spacing not to exceed two seats (approximately 6 feet) on account of the low illumination intensities

PLAN NO. 2.
LOCATION OF LAMPS AND TEST STATIONS
HALF DECK LIGHTING - TWO SEAT SPACING



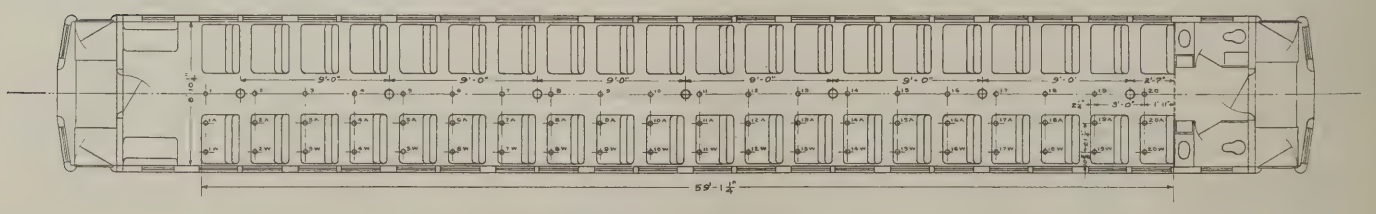
o LOCATION OF ILLUMINATION TEST STATIONS
O LOCATION OF LAMPS

Fig. 4—Location of Lamps and Test Stations and Half Deck Lighting—Two Seat Spacing.

found to possess a slightly higher efficiency, while the half deck system was characterized by slightly better uniformity, though the differences were so small as to be considered negligible. No serious shadows are obtained under normal conditions with either system, but where a large number of people are standing in the aisle, shadows may be produced with center deck lighting which would be objectionable to a person sitting on the aisle side of the seats. This condition of loading of passenger cars, however, rarely exists in steam railway service.

obtained with greater spacing. With gas lighting the lumens emitted by the Pintsch 90 candle power mantle lamp is practically twice that of a 50-watt tungsten lamp with the consequence a greater spacing is usually employed, general practice in coach lighting being 3 seats. A number of tests were made to ascertain the adequacy of 3-seat spacing from the point of view of uniformity, with the idea that if satisfactory distribution of illumination could be obtained with this spacing a larger size of train lighting lamp would be developed for this service. Figures 6 and 7 show comparison of

PLAN NO. 3.
LOCATION OF LAMPS AND TEST STATIONS
CENTER DECK LIGHTING - THREE SEAT SPACING



o LOCATION OF ILLUMINATION TEST STATIONS.
O LOCATION OF LAMPS

Fig. 5—Location of Lamps and Test Stations Center Deck Lighting—Three Seat Spacing.

the illumination obtained on the 45-degree reading planes with 2-seat and 3-seat spacing with electric lighting using clear prismatic reflectors and using light density opal reflectors, respectively. Figure 8 shows results obtained with gas lighting with satin finish Corona globes. Figures 3 and 5 show the location of the light units as used in these tests. As indicated by the illumination curves the distribution of lighting is poor with

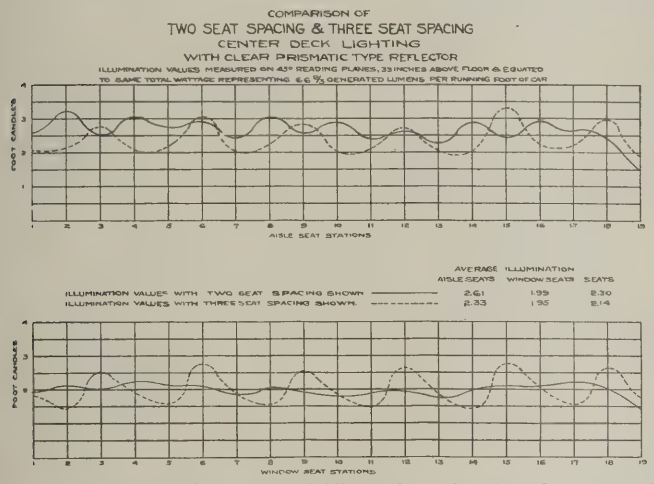


Fig. 6—Two Seat Spacing and Three Seat Spacing Center Deck Lighting with Clear Prismatic Type Reflector.

3-seat spacing, while in addition the efficiency averaged about 7 per cent lower with electric lighting on the wider spacing.

Where the most satisfactory illumination results are desired the spacing of the lighting units for direct systems of lighting in coaches should not exceed 2 seats. With indirect lighting, however, the ceiling may be considered the light source as far as its effect on the illumination produced is concerned. On account of its greater height above the seats as well as the large area of illuminated surface compared with direct lighting units entirely satisfactory results can be obtained with 3-seat (approximately 9 feet) spacing.

(b) Illumination Efficiency Of Various Types of Lighting Units.

The various kinds of lighting units can be classified into groups possessing more or less distinctive characteristics. Table I shows such a grouping as based on

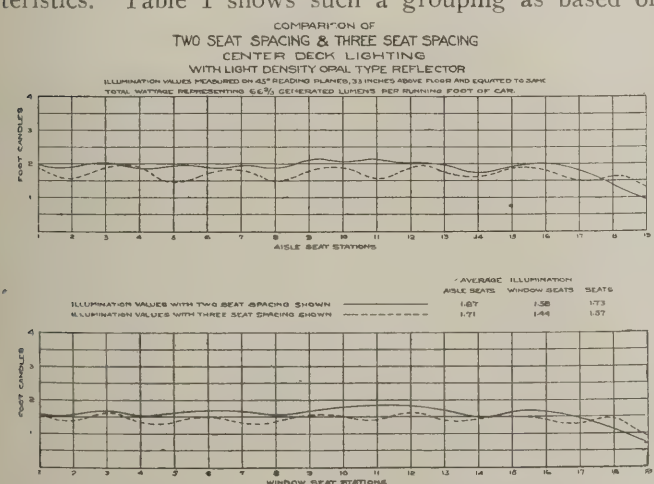


Fig. 7—Two Seat Spacing and Three Seat Spacing Center Deck Lighting with Light Density Opal Type Reflector.

their illumination efficiency, the different types being arranged in the order of their efficiency as measured on the 45-degree planes. Center deck lighting with 2-seat spacing was used with all but the semi-indirect and totally indirect lighting units, which were spaced three seats apart.

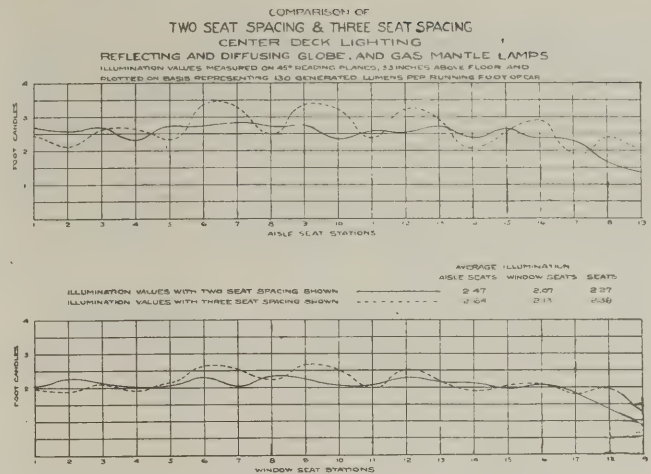

COMPARISON OF
TWO SEAT SPACING & THREE SEAT SPACING
CENTER DECK LIGHTING
REFLECTING AND DIFFUSING GLOBE AND GAS MANTLE LAMPS
AISLE SEAT STATIONS
WINDOW SEAT STATIONS
FOOT CANDLES

Fig. 8—Two Seat Spacing and Three Seat Spacing Center Deck Lighting Reflecting and Diffusing Globe and Gas Mantle Lamps.

TABLE I.
ELECTRIC LIGHTING.

Comparison of Various Types of Lighting Units from Point of View of Illumination Efficiency.

All results reduced to same total wattage representing 66 2/3 generated lumens per running foot of car.

Type of Unit	Average Illumination on 45-Deg. Read'g Planes Foot Candles Aisle Seats	Window Seats	Aver'e.	Illumination Efficiency % Effective Lumens on 45-Degree Planes
Open mouth reflectors—				
Mirrored glass reflectors	3.39	2.18	2.79	39.5
Prismatic clear reflectors	2.66	2.17	2.42	34.2
Heavy density opal reflectors	2.41	1.87	2.14	30.3
Enclosing unit—				
Prismatic reflectors (deep bowl type) and bowl	2.15	1.66	1.89	26.7
Open mouth reflectors—				
Medium density opal reflectors	2.00	1.65	1.83	25.9
Prismatic satin finish reflectors	1.94	1.50	1.72	24.3
Light density opal reflectors	1.79	1.52	1.66	23.5
Semi-indirect units	1.56	1.24	1.40	19.8
Diffusing shades (standard Pullman opal shade)	1.42	1.28	1.35	19.1
Enclosing units—				
Reflecting and diffusing globes (satin finish Corona)	1.44	1.24	1.34	19.0
Reflecting and diffusing type of units	1.46	1.18	1.32	18.7
Prismatic reflector (shallow bowl type) and bowl	1.39	1.09	1.24	17.5
Totally indirect units	1.36	1.11	1.23	17.4
Bare Lamp	1.17	1.13	1.15	16.3
Enclosing unit, light density opal globe	1.09	.97	1.03	14.6

As would be expected, the mirrored glass type of reflector is the most efficient, but on account of being opaque its use can scarcely be considered for direct lighting units for coach service. The clear prismatic type of reflectors come next, followed closely by heavy density type of opal reflector, in fact one of the deep bowl heavy density opal reflectors tested showed a slightly higher efficiency than a similar shape of clear prismatic reflector. While the illumination from the heavy density opal type falls off at the window seats considerably more than from the clear prismatic type, its efficiency is so high that it should possess considerable attraction for those who object to the appearance and the cleaning question involved of the clear prismatic type, but do not wish to sacrifice efficiency.

It should be noted that next in order of efficiency is an enclosing type of unit. The units of this type tested consisted of clear prismatic glass reflector (deep bowl design) with prismatic enclosing bowl, both with and without opal glass envelopes over the reflectors. On

account of their higher first cost as well as maintenance costs when compared with open mouth reflectors, their use for day coach lighting would probably be considered prohibitive by most railroads. However, for parlor, sleeping cars and similar classes of equipment where it is desired to use lighting units in which the bare light source is entirely concealed and glare reduced to minimum yet at the same time possessing high efficiency, this type of unit is to be recommended.

In the next groups come the medium density opal, satin finish prismatic, and light density opal reflectors, fairly close together with reference to their efficiency, in fact the results obtained with certain of the individual types of one class overlap some of the reflectors tested belonging to other of these classes. This may be accounted for that in classifying the different types of units the differentiation between the opal groups is based only on the density of the glass; although the efficiency of opal reflectors depends chiefly on this feature it is but one of the factors that affects it. Attention is drawn to the fact that by satin-finishing the prismatic type of reflector its efficiency is reduced to a value between the medium density opal and light opal reflectors, though some of the best light density opal types (certain of the so-called "white glass" reflectors which have been included in this group) equal it in efficiency.

The low efficiency should be noted of the square opal shades recently put in use on Pullman cars. Though higher than that obtained with the sand blasted shades in general use on these cars, they are lower than that obtained with the semi-indirect type of lighting units tested and about equal to that of the satin finish Corona globe extensively used with gas lighting in coach service.

With the exception of the deep bowl reflector type of prismatic glass enclosing unit specially designed for car lighting there was found to be relatively little difference in the efficiencies of the different types of enclosing units tested whose use has been considered to any extent for car lighting service. These units showed but little higher efficiency than indirect lighting without possessing the advantages of that system.

As might be expected, with the comparatively small ceiling area available for reflecting purposes, except in a few forms of passenger car construction, the efficiency of the indirect lighting system is rather low. Except for a few special cases in passenger car lighting where the questions of efficiency and the cost of a very high standard of cleaning both of the lighting units and the ceiling of the car, are of minor importance, the indirect system of lighting cannot be recommended for general use in passenger car lighting until a decided advancement has been made in improving the efficiency of the tungsten lamp.

The fact that because the character of material or form of construction of the lighting unit identifies it as belonging to one of the groups shown in Table I, is not sufficient evidence from which to assume that its illumination efficiency in similar service will correspond to that given. It is essential that the shape of its photometric curve and the lumens produced in the different zones approximate that obtained with the units used in the tests. (This data for the different units tested is given in Appendix A.)

Gas Lighting.

The variety of lighting units for gas lighting has never been developed to the extent it has for electric lighting. Table II shows the illumination results and efficiency obtained with some of the lighting units in general use for railway service. The data is on the same basis as that given in Table I except that it represents 130 generated lumens per running foot of car (Pintsch 90 candle power mantle lamps on 2-seat spacing) instead of 66 2/3 lumens.

TABLE II. GAS LIGHTING.

Comparison of Various Types of Lighting Units from Point of View of Illumination Efficiency.

Results given on basis representing 130 generated lumens per running foot of car.

Type of Unit	Average Illumination on 45-Deg. Read'g Planes, Foot Candles Aisle Seats	Window Seats	Aver'e. Seats	Illumination Efficiency % Effective Lumens on 45-Degree Planes
Enclosing units—				
Prismatic reflector and bowl, deep bowl type	3.65	3.72	3.69	26.8
Reflecting and diffusing globes (clear Corona)	2.74	2.34	2.54	18.4
Reflecting and diffusing globes (satin finish Corona)	2.47	2.07	2.27	16.5
Medium density opal diffusing globes	2.08	1.52	1.80	13.1
C. R. I. diffusing globes	1.92	1.67	1.80	13.1

The prismatic reflector and bowl unit was practically identical with that used in the tests with electric lighting. As was shown with electric lighting, the efficiency of the reflecting and diffusing type of globes is low. However, on account of the large amount of light produced by gas lamps, the need for using efficient reflectors ois not as great as with electric lighting.

Size of lamps.

It will be noted that with the best arrangement of location of lighting units—center deck lighting with 2-seat spacing and employing the largest standard size of train lighting lamp in general use, the 400 lumen lamp (50-watt), the illumination obtained on the 45-degree reading planes is not as high as could be desired, except possibly with the most efficient types of reflectors. The need of a train lighting lamp of higher lumen capacity is indicated, but at the present time none is available except at an increase in wattage, which from an operating point of view is highly undesirable. With the present standard train lighting lamps, therefore, the use of only the more efficient types of lighting units is recommended for electric lighting where the best illumination results are to be obtained.

(c) Effect Of Color Of Head Lining.

To ascertain the influence of the color of the head lining upon the useful illumination produced, a number of tests were made with direct lighting using the white head lining that was installed for the indirect lighting tests. The coefficient of reflection of the original medium olive head lining installed in the car is 36 per cent while that of the special white head lining is 88 per cent. The tests showed about 10 per cent increase in illumination where light density opal reflectors were used, with which type a considerable amount of light is transmitted by the reflector to the ceiling and from there redirected to the working plane. With clear prismatic type and the more dense types of opal reflectors where the proportion of transmitted light is small there was no appreciable difference in the illumination produced on the working plane with the two colors of head lining.

The results indicate that with direct lighting systems the color of the head lining has no appreciable influence upon the useful illumination produced except with those lighting units in which a considerable proportion of the light is transmitted to the ceiling. A light colored head lining, however, produces a more cheerful effect in the car, and especially where lighting units are used which throw a very small proportion of their light to the ceiling,

eliminates to a great extent the gloomy appearance as obtained with dark head linings under artificial illumination conditions.

It was found impracticable in the investigation to make tests with different colors of interior finish of the car. Adequate test data along these lines is to be desired.

Detail Test Data.

In Appendix A is given in detail the essential data of the illumination tests on the various types of lighting units tested. Attention is called to the fact that in a research of this character it was possible to adopt elaborate methods to insure accuracy which would be impracticable with tests of lesser magnitude. The laboratories of the engineering department of the National Electric Lamp Association were available for frequent calibration of both the instruments and lamps used in the tests. Further, check illumination tests were made daily in which the average results had to check within 2 per cent before the regular test work was allowed to proceed. Experience indicated that without taking necessary precaution large errors can readily occur in work of this character. Your committee feels, therefore, that the results of these illumination tests of various types of lighting units, should, as far as their comparative value is concerned, be accepted as the authentic data with reference to their application to passenger car lighting.

Acknowledgment.

Acknowledgment is made to the Lake Shore & Michigan Southern Railway, Pennsylvania Railroad, Chicago, Burlington & Quincy Railroad, and the Baltimore & Ohio Railroad, as well as to the Safety Car Heating & Lighting Company, Holophane Works of General Electric Company, National Electric Lamp Association, Macbeth-Evans Glass Company, Adams & Westlake Company, and American Car & Foundry Company, for their co-operation in making possible the conducting of this research.

Respectfully submitted,

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H. C. Meloy,
D. P. Morrison,
L. Schepmoes,
A. J. Sweet,
E. W. Jansen.

General Wire and Cable Specifications

No. W-3 1913

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PART I—GENERAL.

The Committee on Wire and Cable Specifications has devoted itself to extending the scope of the 1912 Specifications and improving them to conform with the latest engineering practice.

The 1912 Wire and Cable Specifications relate to wires and cables for potentials up to 600 volts only, whereas

the present specifications cover potentials up to 15,000 volts.

The 1912 Wire Specifications contained no chemical clauses in the section on rubber. These have been added in accordance with the plan of the 1912 Committee.

The Committee recognizes that various grades of rubber insulation may be used with advantage under different conditions, according to the degree of permanence desired, but where great reliability is required, a grade of insulation at least equal to that called for in the following specifications should be used. The Committee does not undertake to express an opinion on the relative merits of compounds with a mineral base, and those containing organic substances.

The chemical clauses of the rubber specifications are those recommended by the Railroads' Rubber Committee appointed in December, 1911.

The order forms in the 1912 Specification were found in practice, to be somewhat difficult for non-technical men to use. This defect has been remedied.

Several changes have been made in the specifications for impregnated paper and varnished cambric, in order to take advantage of recent developments.

A great deal of study was devoted to the subject of potential tests for high voltage cables, and important differences of opinion developed among the members of the Committee. The matter was finally settled by the acceptance of a compromise devised by the three members representing consumers. The general idea of the tests accepted, is illustrated by the curves of Fig. 1. It will be observed that rubber compound is assumed to have a higher or lower dielectric strength than paper or cambric, depending upon whether the insulation is thin or thick, the critical thickness being about 10/32nds of an inch.

The design of cables for potentials in excess of 15,000 volts is in a state of development where standardization would embarrass the manufacturers and retard progress. The Committee, has, therefore, decided to make the specifications cover potentials to 15,000 volts only.

The Committee invited the Wire and Cable Committee of the American Electric Railway Association to send a representative to its meetings in order that the two Associations might have substantially similar specifications. This invitation was accepted and reciprocated and the desired agreement between the specifications of the two Associations has been attained.

In order to facilitate the use of the specifications, the Committee deems it advisable to reprint the entire 1912 Specification with the modifications and additions proposed.

PART II—ORDER FORMS.

The specification (Part III) covers labor and materials for all kinds of wires and cables for railway, power and lighting purposes, but does not specify the size or make-up of any particular kind of wire or cable.

It must, therefore, be supplemented by certain specific data whenever used. This may be accomplished in either of two ways.

1st. The man who is ordering wire or cable may be provided with a series of printed or mimeographed order forms which he fills out and forwards to the Purchasing Agent, who copies the filled-out form and sends it to the manufacturer.

2nd. The man who is ordering wire or cable writes out a complete specification, using in it such clauses as he requires from the General Wire & Cable Specification.

The former of these two plans works better in practice, as it eliminates the preparation and use of a large number of more or less bulky and complicated specifications. It also eliminates the possibility of overlooking any items.

The order form system is in use by several of the most important wire and cable users in the country.

The order forms may be backed with general advice and instructions for filling out, these being for the benefit of the men preparing orders. The Committee has not deemed it advisable to prepare such instructions on account of the impossibility of considering all the conditions to be met.

The types and sizes of wire and cable used in each department should be standardized as far as practicable and a series of properly numbered forms filled out to conform with the standards, should be kept on file in the department. These standard filled-out forms are merely copied when an order form is to be filled out for transmission to the Purchasing Agent.

Eight typical order forms follow. Probably any one user will require only two or three kinds and it may be that other forms will have to be prepared to suit local conditions.

Order Form I.

ORDER FORM FOR BARE OR WEATHERPROOF AERIAL WIRE OR CABLE.

Items	Blanks to be Filled
(a) Quantity required, feet.	
(b) Maximum length, each piece, feet.	
(c) Minimum length, each piece, feet.	
(d) Size of conductor, A. w. g. or Circular mils.	
(e) Material of conductor, hard drawn copper, aluminum, copper-clad steel, phono-electric metal.	
(f) Solid or stranded.	
(g) Stranding, standard or special.	
(h) Number of strands (if special).	
(i) Condition of central wire (if conductor is stranded), hard drawn, semi-hard drawn.	
(j) Number of impregnated (weatherproof) cotton braids, each 1/32nd in. thick.	
(k) Whether to be delivered in coils or on reels.	
(l) Where to be delivered.	
(m) When to be delivered.	
(n) Approximate total cost.*	

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form II.

ORDER FORM FOR BARE CONDUCTORS NOT FOR AERIAL SPANS

Items.	Blanks to be Filled
(a) Quantity required, feet.	
(b) Maximum length, each piece, feet.	
(c) Minimum length, each piece, feet.	
(d) Size of conductor (if not extra flexible) A. w. g. or Circular mils.	
(e) Size of each wire (if extra flexible), A. w. g.	
(f) Material of conductor, soft-annealed copper, aluminum.	

(g) Tinned or not tinned.	
(h) Solid or stranded.	
(i) Stranding, standard or special.	
(j) Stranding (if special), concentric or rope lay.	
(k) Number of strands (if special).	
(l) Number of wires in strand if rope lay.	
(m) Whether to be delivered in coils or on reels.	
(n) Where to be delivered.	
(o) When to be delivered.	
(p) Approximate cost.*	

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form III.

ORDER FORM FOR SINGLE CONDUCTOR INSULATED WIRE OR CABLE FOR INDOOR SERVICE.

Items.	Blanks to be Filled
(a) Quantity required, feet.	
(b) Maximum length, each piece, feet.	
(c) Minimum length, each piece, feet.	
(d) Size of conductor (if not extra flexible). A. w. g. or Circular mils.	
(e) Size of each wire (if extra flexible), A. w. g.	
(f) Material of conductor, soft-annealed copper or hard-drawn copper.	
(g) Tinned or not tinned.	
(h) Solid or stranded.	
(i) Stranding, standard or special.	
(j) Stranding (if special), concentric or rope lay.	
(k) Number of strands (if special).	
(l) Number of wires in strand (if rope lay).	
(m) Voltage of circuit.	
(n) Separator (if any), to be yarn or tape.	
(o) Insulation material, Grade A rubber or Code rubber, or Varnished cambric, or Impregnated paper.	
(p) Thickness of insulation (if special), inches.	
(q) Tapes, rubber filled cotton, number of.	
(r) Number of braids of the following kinds, in the order given, proceeding outward, Impregnated cotton braids, Glazed cotton braids.	
(s) Lead sheath or no lead sheath.	
(t) Whether to be delivered in coils or on reels.	
(u) Where to be delivered.	
(v) When to be delivered.	
(w) Approximate total cost.*	

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form IV.

ORDER FORM FOR SINGLE CONDUCTOR INSULATED WIRE OR CABLE FOR EXPOSED SERVICE.

Items.	Blanks to be Filled
(a) Quantity required, feet.	
(b) Maximum length, each piece, feet.	
(c) Minimum length, each piece, feet.	
(d) Size of conductor (if not extra flexible), A. w. g. or Circular mils.	
(e) Size of each wire (if extra flexible), A. w. g.	
(f) Material of conductor, soft-annealed copper, or hard-drawn copper.	
(g) Solid or stranded.	
(h) Stranding, standard or special.	
(i) Stranding (if special), concentric or rope lay.	
(j) Number of strands (if special).	
(k) Number of wires in strand (if rope lay).	
(l) Voltage of circuit.	
(m) Insulation material. Grade A rubber, Code rubber.	
(n) Thickness of insulation (if special), inches.	
(o) Tapes, rubber-filled cotton, number of.	
(p) Number of braids of the following kinds, in the order given, proceeding outward. Impregnated hemp, Impregnated cotton.	
(q) Lead sheath or no lead sheath.	
(r) Steel tape armor or no armor.	
(s) Jute over armor (if not wanted say "no").	
(t) Pressure wire (if any), size.	
(u) Pressure wire (if any), location. Stranded with conductor, or Stranded with conductor, or between insulation and braids.	
(v) Pressure wire (if any), insulation material.	
(w) Whether to be delivered in coils or on reels.	
(x) Where to be delivered.	
(y) When to be delivered.	
(z) Approximate cost.*	

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form V.

ORDER FORM FOR SINGLE CONDUCTOR INSULATED WIRE OR CABLE FOR UNDERGROUND CONDUIT SERVICE

Items.	Blanks to be Filled
(a) Quantity required, feet.	
(b) Maximum length, each piece, feet.	
(c) Minimum length, each piece, feet.	
(d) Size of conductor (if not extra flexible), A. w. g. or Circular mils.	
(e) Size of each wire (if extra flexible), A. w. g.	
(f) Voltage of circuit.	
(g) Insulation material. Grade A rubber compound. Impregnated paper, or Varnished cambric.	
(h) Thickness of insulation (if special), inches.	
(i) Pressure wire (if any), size.	
(j) Pressure wire (if any), location, stranded with conductor, or between insulation and braid or sheath.	
(k) Pressure wire (if any), insulation material.	
(l) Whether to be delivered in coils or on reels.	
(m) Where to be delivered.	
(n) When to be delivered.	
(o) Approximate total cost.*	

The conductor shall be of soft-annealed copper with standard stranding. The insulated conductor shall be enclosed in a lead sheath.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form VI.

SINGLE CONDUCTOR SUBMARINE AND OTHER ARMORED CABLES.

Items.	Blanks to be Filled
(a) Quantity required, feet.	
(b) Maximum length, each piece, feet.	
(c) Minimum length, each piece, feet.	
(d) Size of conductor, A. w. g. or Circular mils.	
(e) Number of strands, each conductor (if special).	
(f) Voltage of circuit.	
(g) Insulation, material, grade A rubber, or varnished cambric.	

(h)	Thickness of insulation (if special), inches.	
(i)	Pressure wire (if any), size.	
(j)	Pressure wire (if any), location, stranded with conductor, or between insulation and braid or sheath.	
(k)	Pressure wire (if any), insulation material.	
(l)	Tapes, rubber filled cotton, number of.	
(m)	Impregnated cotton braids, number.	
(n)	Lead sheath or no lead sheath.	
(o)	Thickness of sheath (if special), inches.	
(p)	Armor, steel wire or steel tape.	
(q)	Jute over armor (if not wanted, say "no").	
(r)	Whether to be delivered in coils or on reels.	
(s)	Where to be delivered.	
(t)	When to be delivered.	
(u)	Approximate total cost.*	

The conductor shall be of soft-annealed copper. All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form VII.

ORDER FORM FOR SINGLE CONDUCTOR WIRES AND CABLES FOR TRAIN LIGHTING.

	Items.	Blanks to be Filled
(a)	Quantity required, feet.	
(b)	Maximum length, each piece, feet.	
(c)	Minimum length, each piece, feet.	
(d)	Size of conductor, A. w. g.	
(e)	Number of strands.	
(f)	Voltage of circuit.	
(g)	Separator (if any), to be yarn or tape.	
(h)	Thicknes of insulation, inches.	
(i)	Tapes, rubber filled cotton, number of.	
(j)	Number of impregnated cotton braids.	
(k)	Whether to be delivered in coils or on reels.	
(l)	Where to be delivered.	
(m)	When to be delivered.	
(n)	Approximate total cost.*	

The conductor shall be of tinned soft-annealed copper, and shall be insulated with grade A rubber.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

Order Form VIII.

ORDER FORM FOR MULTIPLE CONDUCTOR CABLE.

	Items.	Blanks to be Filled
(a)	Quantity required, feet.	
(b)	Maximum length, each piece, feet.	
(c)	Minimum length, each piece, feet.	
(d)	Number of conductors.	
(e)	Size of each conductor (if not extra flexible), A. w. g. or Circular mils.	
(f)	Size of each wire (if extra flexible), A. w. g.	
(g)	Stranding, standard or special.	
(h)	Stranding (if special), concentric or rope lay.	
(i)	Number of strands in conductor (if special).	
(j)	Number of wires in strand (if rope lay).	
(k)	Voltage between conductors.	
(l)	Voltage from conductors to ground.	
(m)	Separator (if any), to be yarn or tape.	
(n)	Insulation over each conductor, material, grade A rubber, or Code rubber, or varnished cambric, or impregnated paper.	
(o)	Thickness of insulation over each conductor (if special), inches.	
(p)	Covering over each insulated conductor, rubber-filled cotton tape, or impregnated cotton braid, or glazed cotton braid.	
(q)	Tracer in each layer of conductors (state whether required).	
(r)	If braids are to be differently colored as tracers, state sequence of colors.	
(s)	Jute laterals (state whether required).	
(t)	Pressure wire (if any), size A. w. g.	
(u)	Tape over each layer of conductors (if required), material, rubber-filled cotton, or dry cotton, or impregnated paper, or dry paper, or varnished cambric.	
(v)	Insulation over all conductors, i. e., belt (if any), material, grade A rubber, or varnished cambric, or impregnated paper.	
(w)	Thickness of insulation belt (if special), inches.	
(x)	Tape over finished group of conductors (or over belt, if any), material, impregnated cotton, or varnished cambric.	
(y)	Jute filler under braid or sheath (state whether required).	
(z)	Jute filler (if other than 8-ply), state size required.	
(aa)	Number of braids of each of following kinds, in the order given, proceeding outward, impregnated hemp braids, impregnated cotton braids, glazed cotton braids.	
(ab)	Lead sheath or no sheath.	
(ac)	Thickness of sheath (if special), inches.	
(ad)	Armor (if any), steel wire or steel tape.	
(ae)	Jute over armor (if not wanted, say "no").	
(af)	Maximum overall diameter (if limit is necessary), inches.	
(ag)	Whether to be delivered in coils or on reels.	
(ah)	Where to be delivered,	
(ai)	When to be delivered.	
(aj)	Approximate total cost.*	

The conductors shall of soft-annealed copper, tinned if rubber insulated, otherwise not tinned. The insulation of the pressure wire, if any, shall be of the same material as on the main conductors. Two conductor cables shall be flat unless otherwise specified. If there are more than two conductors, they shall be assembled helically.

All workmanship and materials shall conform in every respect with the requirements of the current issue of the General Wire and Cable Specifications of the Association of Railway Electrical Engineers.

*For the guidance of the Purchasing Agent.

PART III—GENERAL SPECIFICATIONS.

General Clauses.

1. (a) *Workmanship and Materials*: All workmanship and materials shall be the best of their respective kinds and shall be in full accord with the best modern engineering practice.

(b) *Inspection*: The wire or cable shall be open for inspection by an authorized representative of the purchaser, who shall be afforded all necessary facilities to assure him that the materials used, and the process of manufacture, conform with the specifications. The braid or sheath shall not be applied until the inspector has approved (in writing) the insulation.

(c) *Notification*: The contractor shall notify the designated representative of the purchaser sufficiently in advance of the completion of the wire and cable to enable inspection to be arranged for.

(d) *Tests*: The manufacturer shall furnish suitable apparatus and shall make the tests in the presence of the railroad company's representative, who shall be allowed every reasonable facility to assure himself that the requirements of this specification have been complied with,

except that when chemical analysis of rubber insulation is required it shall be made by the purchaser.

(e) *Definition of Cable Size*: The combined area of the wires when laid out straight and measured at right angles to their axes shall be not less than the specified gauge or circular mils. Unless otherwise specified, conductors shall be of soft-drawn copper.

(f) *Thickness of Insulation*: Unless otherwise specified, the thickness of insulation for potentials up to 7,000 volts, shall be the minimum allowed by the National Board of Fire Underwriters, as summarized in Table I. For higher voltages, the thickness of insulation will depend upon the conditions of service.

TABLE I.

THICKNESS OF INSULATION RECOMMENDED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS.

	Working Voltage.					
	0-600	1,500	2,500	3,500	5,000	7,000
A. W. G.	Thickness of Insulation, 64ths Inch.					
14	3	4	6	8	12	16
12	3	4	6	8	12	16
10	3	4	6	8	12	16
8	3	4	6	8	12	16
6	4	5	6	8	12	16
4	4	5	6	8	12	16
2	4	5	6	8	12	16
1	5	6	7	8	12	16
0	5	6	7	8	12	16
00	5	6	7	8	12	16
000	5	6	7	8	12	16
0000	5	6	7	8	12	16
Cir. Mils.						
225,000	6	7	8	9	12	16
300,000	6	7	8	9	12	16
400,000	6	7	8	9	12	16
500,000	6	7	8	9	12	16
600,000	7	8	9	10	12	16
700,000	7	8	9	10	12	16
800,000	7	8	9	10	12	16
900,000	7	8	9	10	12	16
1,000,000	7	8	9	10	12	16
1,250,000	8	9	10	11	14	18
1,500,000	8	9	10	11	14	18
1,750,000	8	9	10	11	14	18
2,000,000	8	9	10	11	14	18

(g) *Stranding*: Unless otherwise specified, the stranding shall be concentric and in accordance with the following table:

TABLE II.

Range of Sizes.	Minimum Number of Wires in Conductor.
2,000,000—1,600,000 Circ. Mills.	127
1,500,000—1,100,000	91
1,000,000— 550,000	61
500,000— 250,000	37
No. 0000—No. 1 A. W. G.	19
2— 8	7
Smaller Sizes	1

The following stranding is recommended for extra flexible conductors:

TABLE III.

Approximate Size, A. W. G.	Number of Wires of Standard A. W. G. Gauge in Conductor.
0000—00	127
0— 1	91
2— 6	61
8—13	37
14 and smaller	19

(h) *Repairs and Joints of Insulation*: If exigencies of manufacture require repairs or joints in the insulation, the work shall be done in such a way as to leave the repaired part or joint, and all parts effected by it, as strong and durable electrically as the remainder of the insulation. In the case of rubber insulation, patches and joints shall be properly vulcanized.

Electrical Tests.

2. (a). *High Potential Test*: The high potential test voltage shall be applied for five (5) minutes, shall have a frequency not exceeding one hundred (100) cycles per second, and shall approximate as closely as possible to sine wave. The source of energy shall be of ample capacity.

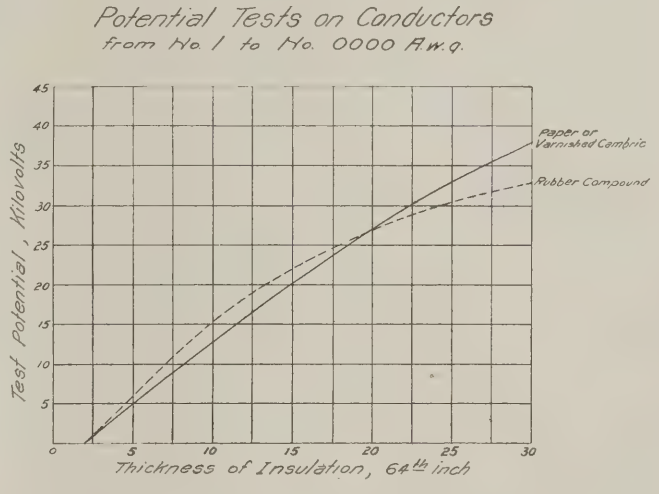


TABLE IV.

Test Potentials, Kilovolts.

FIVE-MINUTE TESTS.

Rubber—Use 100 per cent of following potentials.

Varnish Cloth—Use 75 per cent of following potentials.

Impregnated Paper—Use 75 per cent of following potentials.

Size of Conductors.	Thickness of Insulation, 64th Inch.							
	2	3	4	5	6	7	8	10
18 A. W. G.	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
16	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
14		2.5	5.0	6.0	7.0	8.0	9.0	11.0
12		2.5	5.0	6.0	7.5	8.5	9.5	11.5
10		3.0	5.0	6.5	8.0	8.5	10.0	12.0
8		3.0	5.0	7.0	8.0	9.5	11.0	13.0
6			5.0	6.5	8.5	10.0	11.5	14.0
4			4.5	6.5	8.5	10.0	11.5	14.5
2			4.0	6.0	8.0	10.0	12.0	15.0
1			4.0	6.0	8.0	10.0	12.0	15.5
0				5.5	8.0	10.0	12.0	15.5
00				5.0	7.5	9.5	11.5	15.5
000				5.0	7.5	9.5	11.5	15.5
0000				4.5	7.0	9.0	11.5	15.5
250,000 C. M.				4.0	6.5	9.0	11.0	15.5
500,000				2.5	5.0	7.5	10.0	14.5
750,000						6.5	9.0	14.0
1,000,000						5.5	8.0	13.0
1,250,000							7.5	12.5
1,500,000							7.0	12.0
1,750,000							6.5	11.5
2,000,000							5.0	10.5

(For intermediate sizes use the voltages corresponding to the next larger size, having the same thickness of insulation.)

TABLE V.

Test Potentials, Kilovolts.

		Thickness of Insulation, 64ths Inch. 12	14	16	18	20	22	24	26	28
6-5 A. w. g...	Rubber	16	18	20	22	23	25	26	28	29
	V. C. or Paper	15	17	19	21	23	26	28	30	31
4-2 A. w. g...	Rubber	17	19	22	24	25	26	28	29	30
	V. C. or Paper	15	17	20	23	25	28	30	32	34
1-0000 A. w. g.	Rubber	18	21	23	25	27	28	30	31	32
	V. C. or Paper	16	19	22	24	27	30	32	34	36
250,000 & larger	Rubber	19	22	24	26	28	30	31	33	34
	V. C. or Paper	17	20	23	25	28	31	33	36	38

(b) *Insulation Resistance*: The insulation resistance shall be measured after the high potential test, and shall be made from a one minute electrification with a battery having an e.m.f. of not less than 100 and not more than 500 volts, and the results corrected to the standard temperature of 15.5 deg. cent. (60. deg. fahr.)

blacken a piece of clean untinned copper wire in five (5) seconds.

Separator.

5. The separator may consist of soft cotton yarn (which may be braided), or of paper or muslin tape. With untinned conductors, the separator shall completely cover the conductors; with tinned conductors, it is desirable that the separator shall allow the insulation sufficient contact with the conductor to prevent the conductor sliding in the insulation.

Grade A Rubber Compound.

6. (a). *Composition*: The compound shall consist of Fine Para or Smoked First Latex rubber and a mineral base. It shall contain only the following ingredients:

Rubber.
Sulphur.
Inorganic mineral matter.

TABLE VI.

Megohm-Miles at 60° F. Based Upon the Constant 4000.

1 Minute Electrification.

Rubber, minimum shall be 100% of following.
Varnished Cloth, minimum shall be 15% of following.
Impregnated Paper, minimum shall be 12½% of following.

Size of Conductors.	Thickness of Insulation, 64ths Inch. 2	3	4	5	6	7	8	10	12	14	16	18	20	22	24	26	28
18 A. W. G.	1600	2050	2450	2800	3000	3200	3400	3750	4050	4300	4500	4700	4900	5000	5150	5300	5400
16	1400	1800	2150	2400	2650	2850	3050	3400	3650	3950	4150	4350	4500	4650	4800	4900	5050
14		1550	1850	2150	2350	2550	2650	3050	3350	3550	3800	3950	4100	4300	4400	4550	4650
12		1350	1600	1850	2050	2250	2400	2750	3000	3250	3400	3600	3750	3900	4050	4150	4300
10		1150	1350	1600	1800	2000	2150	2400	2650	2900	3100	3250	3400	3550	3700	3800	3900
8		850	1050	1250	1450	1650	1750	2050	2200	2400	2600	2750	2900	3050	3150	3250	3350
6			850	1050	1200	1350	1450	1750	1950	2100	2300	2450	2550	2700	2800	2900	3000
4			750	850	1000	1150	1250	1450	1650	1850	2000	2150	2250	2400	2500	2600	2700
2			650	750	850	950	1050	1250	1450	1600	1700	1850	1950	2100	2200	2300	2400
1			600	650	750	850	1000	1150	1350	1450	1600	1750	1850	1950	2050	2150	2250
0				600	700	800	950	1050	1200	1350	1500	1600	1700	1800	1900	2000	
00				550	650	750	850	950	1050	1250	1350	1500	1600	1700	1800		
000				500	600	650	750	850	1000	1150	1250	1350	1450	1550			
0000				450	550	600	650	800	950	1050	1150	1250	1350	1450			
250,000 C. M.				400	475	575	625	725	875	1000	1100	1200	1275				
350,000				350	425	475	525	675	775	850	950	1050	1125				
500,000				300	375	400	475	575	675	750	850	900					
750,000						325	400	475	525	625	700	775					
1,000,000						300	325	400	475	550	625						
1,250,000							325	375	425	500	575						
1,500,000							300	325	400	475							
1,750,000							275	300	375	450							
2,000,000							200	275	325	425							

Copper, Soft, Semi-Hard and Hard Drawn.

3. The current issue of the specifications of the American Society for Testing Materials shall be complied with in every respect. Sufficient data on the conductivity of tinned wire not being available, allowance will be made in conductivity by the inspector.

Tinning.

4. Tinned wire shall be provided with a heavy uniform coating of commercially pure tin without projections. Where tinned wire is supplied but not called for, the following test is not required.

Samples of wire, before stranding or covering, shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid of specific gravity 1.088 and temperature 60° F. for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty (30) seconds and again washed. This operation shall be repeated three (3) times and upon the completion of the fourth cycle the sample shall show no sign of blackening.

The sodium sulphide solution shall contain an excess of sulphur and shall have sufficient strength to thoroughly

Refined solid paraffin or ceresin.
It shall not contain either red lead or carbon.

(b) *Results of Analysis*: After vulcanization, the compound shall conform to the following requirements, the results to be expressed as percentages of the whole sample:

Rubber, between	30 and 33% by wt.
Waxy Hydrocarbons, under	4
Free Sulphur, under	0.7

After vulcanization the compound shall conform to the following requirements, results to be taken between the limits given, in proportion to the percentage by weight of rubber found:

Limits allowed for 30% Rubber Compound.

	Maximum	Minimum
Saponifiable extract	1.35	0.55%
Unsaponifiable resins	0.45	....
Chloroform extract	0.90	....
Alcoholic potash extract	0.55	....
Specific gravity	....	1.75%

Limits allowed for 33% Rubber Compound.

	Maximum	Minimum
Saponifiable extract	1.50	0.60%..
Unsaponifiable resins	0.50	....
Chlorofrom extract	1.00	....
Alcoholic potash extract	0.60	....
Specific gravity	....	1.67%

The acetone solution shall not fluoresce.

The acetone extract (60 cc.) shall be not darker than a light straw color.

Hydrocarbons shall be solid, waxy, and not darker than a light brown.

Chloroform extract (60 cc.) shall be not darker than a straw color.

Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to this specification.

Failure to meet any requirement of this specification will be considered sufficient cause for rejection.

The compound will be analyzed by the procedure recommended by the Railroads' Rubber Committee.

(c) *Concentric Application*: The conductor shall be tinned. The compound shall be applied concentrically about the conductors and shall fit tightly thereto. If necessary, in order to achieve this result on insulated conductors of greater diameter than three-eighths (3/8) of an inch over the insulation, a tape shall be applied over the insulation before vulcanization. Such tape, if it does not comply with the tape specification given hereinafter, will be additional to any which may be required in the accompanying wire specification form.

(d) *Tensile Strength and Elongation*: A sample which may be of entire, segmental, or approximately rectangular cross-section, at the discretion of the manufacturer, shall be cut from the insulated conductor by means of a sharp knife. The sample shall be bent in every direction to magnify and reveal any surface incision or imperfection which may exist. A portion of the sample without such defects and having a free length of not less than two (2) inches shall then be stretched at the rate of twelve (12) inches per minute, until it breaks. The marks shall be placed on the insulation before its removal from the conductor. Five (5) samples from every 25,000 feet or less shall be tested in this way. Tensile strength and elongation tests shall be made on unstretched samples.

The compound shall conform to the following limits:

TABLE VII.

Property.	Thickness, Inches 12/64-in. or less. Maximum.	Minimum.	Over12/64-in. Maximum.	Minimum.
Tensile strength, lbs. per sq. in. (each sample)...	....	1000	....	1000
Elongation in two (2) in. length at break (times original length).	....	5	....	4
Elongation 5 seconds after release when stretched at the rate of 12 in. per minute to 3 times its length	20%	....	20%	....

(e) *Electrical Tests*: Electrical tests shall be made upon all wire or cable after at least twenty-four (24) hours immersion in water while still immersed and before the application of any covering other than the tape or braid used in vulcanization. The insulated conductor shall successfully meet the high potential tests specified in Tables IV and V. In the case of rubber insulated multiplex cables, the insulation resistance shall be measured before assembling the conductors. All additional electrical test shall be made on lead covered cable only and shall consist of a high potential test to be made upon the cable after assembling and leading and without immersion in water. In the case of multiplex cables, this test shall be made successively between each conductor and the other conductors and sheath.

The insulation resistance shall be not less than is given in Table VI.

The insulation resistance (megohms) at a given temperature shall be reduced to that at 60 deg. Fahr. by dividing by the coefficient in Table VIII corresponding to that temperature.

TABLE VIII.

(Tests shall be made at temperatures within the scope of this table).

Temperature Degrees Fahr.	Coefficient shall not be greater than	Temperature Degrees Fahr.	Coefficient shall not be less than
46	1.44	60	1.000
47	1.41	61	.974
48	1.37	62	.949
49	1.34	63	.925
50	1.30	64	.901
51	1.27	65	.878
52	1.24	66	.855
53	1.20	67	.833
54	1.17	68	.812
55	1.14	69	.791
56	1.11	70	.771
57	1.09	71	.751
58	1.06	72	.732
59	1.03	73	.713
60	1.00	74	.695
..	....	75	.677

Varnished Cloth Insulation.

7. (a) *Description*: The insulation shall consist of a closely woven cotton cloth and a viscous filler. Each surface of the cloth shall have smooth, continuous films of varnish and shall be free from wrinkles, blisters, and all other imperfections. It shall be thoroughly impregnated with insulating compound, shall be pliable and shall have no tendency to crack when doubled on itself.

(b) *Filler*: The filler shall be a viscous, moisture-repelling insulating compound, whose dielectric constant is similar to that of the varnished cloth insulation and of such a nature as to have no deleterious effect upon the varnish. It shall also prevent the tapes from unwrapping when cut, but will allow the layers to slide upon each other when the cable is bent.

(c) *Assembly*: The insulating cloth shall be applied in the form of tape wound on helically and reversed at least every two layers. The tapes shall be of such widths that for different diameters of cable they will lie smoothly and be free from wrinkles; the turns shall overlap and the joints in successive layers shall be staggered. The filler shall be so applied between layers as to exclude all air, the whole forming a hard, semi-flexible wall of insulation.

(d) *Tape*: A layer of cloth tape thoroughly filled with a rubber compound lapping one-fourth of its width shall be applied over the cloth insulation.

(e) *Electrical Tests*: Each and every length of cable shall meet the specified electrical tests. Braided wires shall be tested after twelve hours immersion in water and before the braid is applied; lead covered conductors shall be tested against the sheath with sheath grounded. Multiplex cables shall be tested between each conductor and the other conductors and sheath or ground in multiple.

(f) *Temperature Coefficient*: At whatever temperature the cable may be tested, the megohms shall be not

less than specified in Table IX. Should a cable tested in air fail to meet the above requirements, the manufacturer may immerse the cable in water to obtain a constant temperature.

TABLE IX.

(Tests shall be made at temperatures within the scope of this table).

Coefficient shall be not greater than	Temp. Deg. Fahr.	Temp. Deg. Fahr.	Coefficient shall be not less than
40-45	2.0	61-65	0.7
46-50	1.5	66-70	0.5
51-55	1.2	71-75	0.4
56-60	1.0	76-80	0.3
		81-85	0.2
		86-90	0.15
		91-95	0-10
		96-100	0.05
		101-105	0.03

Impregnated Paper Insulation.

8. (a) *Description*: The insulation shall consist of a manila paper applied helically, firmly and evenly to the conductor, and then thoroughly impregnated with an insulation compound. The cable shall be pliable and shall show no tendency to harden injuriously at 0 deg. cent.

(b) *Paper*: The paper shall contain no free acids or free alkalis. Tensile strength tests shall be made upon paper taken from the finished cable, both from conductor and jacket, if any. Test pieces ten feet in length shall be selected, looped and tension applied at the loop through a mandrel, the diameter of which is equal to the width of the paper. The test shall be as follows:

5,000 pounds per square inch for 5 minutes, and
then 6,500 pounds per square inch for 1 minute.

Acceptance shall be based upon the average of six tests on sample selected at random from each order, by the inspector.

(c) *Compound*: The compound shall be applied so as to exclude all air and moisture and shall contain no free mineral acid or other substances which have a deleterious effect upon paper.

(d) *Electrical Tests*: Each and every length of cable shall conform to the specified electrical tests. No immersion is required before testing. The potential test shall be made between conductor and sheath with the sheath grounded. Multiplex cables shall be tested between each conductor and sheath or ground, in multiple.

Braids.

9. (a) *Description*: Braid shall be closely woven of cotton thread, at least two-ply, thoroughly impregnated with an insulating waterproof compound and finished with a black insulating compound thoroughly slicked down. The compound shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200° F. The thickness shall be not less than given in the following table:

TABLE X.

Diameter Over the Insulation, Inches.	Thickness of Braid, Inches, not less than.
.160	.018
.290	.028
.530	.038
1.000 and over	.053

For intermediate diameters use next smaller diameter.

Note:—The above does not apply to fancy or special braids for fixtures, etc.

(b) *Tests*: A six inch sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 70 degrees F. for a period of twenty-four hours. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent of the weight exclusive of copper and insulation before submersion. The compound shall not drip at a temperature of 125° F.

Rubber Filled Cloth Tape.

10. The tape shall consist of a cotton cloth not lighter than one (1) pound per four (4) yards 36 inches wide with not less than 56x60 picks per inch, thoroughly filled with a rubber compound. The tape shall be applied spirally, overlapping not less than one-quarter of its width. The following table gives the maximum width of tape allowed:

TABLE XI.

Diameter Over Insulation, Inches.	Maximum Width of Tape.
2.00	5″
1.75	4—½″
1.50	4″
1.25	3—½″
1.15	3—¼″
1.00	3″
.88	2—¾″
.75	2—⅜″
.62	2″
.50	1—¾″
.44	1—½″
.38	1—⅜″
.31	1—⅛″
.25	⅞″
.19	¾″
.16	⅝″

For intermediate diameters use next smaller diameter.

Sheath.

11. (a) *Thickness*: Unless otherwise specified, the sheath shall have an average thickness of not less than that indicated in the tabulation next following, and the minimum thickness shall in no place be less than ninety (90) per cent of the required average thickness.

TABLE XII.

Diam. of Core, Inches.	Corresponding Thickness of Sheath in Inches. Paper Insulation.	Rubber or Var. Cloth Insulation.
—0.29	5/64	4/64
0.30—0.69	6/64	5/64
0.70—1.24	7/64	6/64
1.25—1.99	8/64	7/64
2.00—2.69	9/64	8/64
2.70—over	10/64	9/64

For intermediate diameter use next smaller diameter.

(b) *Composition*: The sheath shall consist of commercially pure lead for all cables having a core diameter (i. e., internal diameter of the sheath) less than two inches; for cables having a core diameter equal to two (2) inches or more the sheath shall consist of an alloy of lead and commercially pure tin containing not less than one (1) per cent of tin.

Wire Armor.

12. If the cable is rubber insulated, it shall be covered with tape, braid, or other suitable protection before passing through the asphalt compound.

(a) *Armor*: The core of the cable shall be run through a hot asphalt compound, served with a layer of jute yarn, run through hot asphalt again, and then laid with galvanized wire armor.

(b) *Size of Armor Wire*: The proper size of armor wire will depend upon the conditions of service; the latitude allowed in the following table represents the differ-

TABLE XIII.

Diameter of Cable Under Jute Bedding, Inches.	Armor Wire U. S. (Steel) W. G.	Jute Bedding Under Armor. Measured in Finished Cable, Inches
0.00—0.50	14—13	2/32 minimum
0.44—0.69	12	2/32
0.63—1.00	10	2/32
0.88—1.50	8	2/32
1.25—2.00	6	2/32
1.30—larger	4	2/32

ence arising from such difference in service conditions. Unless otherwise specified, the armor wire shall be the minimum size.

(c) *Lay*: The armor shall be applied closely without appreciable space between adjacent wires. The lay shall be from eight to twelve times the pitch diameter.

(d) *Finish*: The armored cable shall be run through hot asphalt compound, served with a layer of the best three-ply 14 lb. hard twisted jute yarn spun in a close short lay, run through hot asphalt compound, then served with a second layer of three-ply, 14 lb. jute yarn, run through hot asphalt compound and finally run through some material to prevent sticking.

(Under certain conditions, the purchaser may find it advisable to specify the omission of the outer jute covering.)

(e) *Direction of Lay*: Successive layers of jute or jute and armor shall be laid in opposite directions. In the case of multiple conductor cable armored without lead, the outside layer of conductors shall be put on with a right hand lay. The armor shall be put on with a left hand lay.

(f) *Definition of Lay*: The direction of lay is defined as the lateral direction in which the wires run over the top of the cable as they recede from an observer looking along the axis of the cable.

(g) *Armor Wire*: The armor wire shall consist of a galvanized mild steel wire of uniform diameter, free from all cracks, splits or other flaws. Samples shall be taken (at random) from ten per cent of the coils to be used, for each of the following tests. At least eighty per cent of the samples shall fulfill the conditions of the test in order that the whole lot may be considered satisfactory.

(h) *Tensile Strength Test*: The wire must have a tensile strength of fifty thousand (50,000) pounds per square inch and an elongation of not less than ten per cent (10%) in eight inches.

(i) *Galvanizing Test*: Thoroughly clean a sample to remove all dirt and grease, rinse in clean water and wipe dry with a clean cloth or cotton waste. Immerse for one minute in a solution of copper sulphate of specific gravity 1.186 at 65° F., rinse in clean water and wipe dry. Repeat this operation until the samples have been immersed four times. After these immersions no sample shall show any bright deposit of copper. The samples shall be approximately straight and the ends protected with paraffin. The solution shall be saturated with copper sulphate to which an excess of C. P. cupric oxide has been added and shall be maintained at 60°-65° F. during the test.

(j) *Flexibility Test*: The armor wire shall admit of bending around a spindle of ten times the diameter of the wire and back again without developing cracks of the galvanizing which are visible to the naked eye.

Steel Tape Armor.

13. (a) *Description*: The core of the cable shall be run through a bath of hot asphalt compound, served with a layer of 14 lb. jute yarn, spun on with a close short lay, run through hot asphalt compound, armored with a steel tape; armored with second steel tape; run through hot asphalt compound, served with a layer of one hundred pound jute yarn with a close short lay, run through hot asphalt compound and finished by running through some material to prevent sticking. If the cable is rubber insulated, it shall be covered with tape, braid, or other suitable protection before passing through the asphalt compound. Each layer of jute shall be applied in the reverse direction to the adjacent layer. The space between adjacent turns of steel tape shall not exceed one-tenth (1/10) the width of the steel tape.

(b) *Armor Tape*: The tape and jute under armor, after armoring, shall conform to the following table:

TABLE XIV.

Cable Diameter Before Armoring, Inches	Maximum Width Steel Tape, Inches.	Minimum Thickness Each Tape, Inches.	Minimum Thickness Under Armor, Inches.
—0.45	½	0.02	0.06
0.46—0.75	¾	0.02	0.06
0.76—1.00	1	0.03	0.07
1.01—1.40	1—¼	0.03	0.07
1.41—1.70	1—½	0.04	0.08
1.71—2.00	1—¾	0.04	0.08
2.01—over	2	0.05	0.09

Cable Reels.

14. (a) *General*: Each reel shall consist of a wooden drum with wooden discs or heads securely fastened thereto.

(b) *Bushings*: Each disc or head of the reel shall be provided with an iron plate or cast iron bushing in the center of which shall be a hole two and one-half (2½) inches in diameter. The plates or bushings shall be secured to the head by means of bolts or lags through the head.

(c) *Covering*: Insulated cable shall be thoroughly covered with burlap before lagging is applied.

(d) *Lagging*: When used for insulated cable the reels shall be suitably lagged; when used for bare cable, the lagging of the reel shall be replaced by a burlap covering securely bound to the cable.

(e) *Chocking*: Reels shall be properly chocked in the car so that there shall be no movement of reels during transit.

PART IV.

TERMINOLOGY.

The following terminology which should be used in specifications and orders is based upon a study of this subject by the Bureau of Standards, and upon a canvass of wire manufacturers and users made by a member of this committee. The Standards Committee of the A. I. E. E. also has the subject under consideration, and when their report is issued, it should supersede the following:

Definitions.

	Remarks.
1. Wire: A slender rod or filament of metal.	The definition restricts the term to what would ordinarily be understood by the term solid wire. The word "slender" is used in the general sense of long in comparison with the diameter. If the wire is covered with insulation, it is properly called an insulated wire; while primarily the term **wire** refers to the metal, nevertheless when the context shows that the wire is insulated the ferm wire will be understood to include the insulation.
2. Conductor: A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.	The term **conductor** is not to include a combination of conductors insulated from one another, which would be suitable for carrying several different electric currents. Rolled conductors (such as busbars) are, of course, conductors but are not considered under the terminology here given.
3. Stranded Conductors: A conductor composed of a group of wires or any combination of groups of wires.	The wires in a stranded conductor are usually twisted or braided together.
4. Cable: (1) A stranded conductor (single-conductor cable), or (2) a combination of conductors insulated from one another (multiple-conductor cable).	The component conductors of the second kind of cable may be either solid or stranded, and this kind of cable may or may not have a common insulating covering. The first kind of cable is a **single conductor**, while the second kind is a group of several **conductors**. The term **cable** is applied by some manufacturers to a solid wire, heavily insulated and lead-covered; this usage arises from the man-

ner of the insulation, but such a conductor is not included under this definition of "cable." The term "cable" is a general one but in practice it is usually applied only to the larger sizes. A small cable is called a "stranded wire" or a "cord," both of which are defined below. Cables may be bare or insulated, and the latter may be armored with lead or with steel wires or bands. In all cases, a cable is a complete conductor, not a part of one.

Many American wire manufacturers use the word strand to designate a group of wires twisted together, but this use should be discouraged.

5. Strand: One of the wires or groups of wires of any stranded conductor.

6. Stranded Wire: A group of small wires used as a single wire.

There is no sharp dividing line of size between a "stranded wire" and a "cable." If used as a wire, for example, in winding inductance coils or magnets, it is called a stranded wire and not a cable. If it is substantially insulated, it is called not a stranded wire, but a "cord" defined below.

7. Cord: A small cable, very flexible and substantially insulated to withstand wear.

There is no sharp dividing line between a "cord" and a "cable," and likewise no sharp dividing line in respect to the character of insulation between a "cord" and a "stranded wire."

8. Concentric Strand: A strand composed of a central core surrounded by one or more layers of helically laid wires or groups of wires.

9. Concentric Lay Cable: A concentric strand used as a completed cable.

This is a special case of the concentric lay cable just defined.

10. Concentric Rope Lay Cable: A cable composed of a central core surrounded by one or more layers of helically laid groups of wires.

11. N-Conductor Cable: A combination of N conductors insulated from one another.

It is not intended that the name as here given be actually used. One would, instead, speak of a 3-conductor cable, a 12-conductor cable, etc. In referring to the general case, one may speak of a "multiple-conductor cable."

12. N-Conductor Concentric Cable: A cable composed of an insulated central conducting core with (N-1) tubular stranded conductors laid over it concentrically and separated layers of insulation.

Usually only 2-conductor or 3-conductor. Such conductors are used in carrying alternating currents. The remarks on the expression "N-Conductor" given for the preceding definition, applies here also.

13. Duplex Cable: Two insulated single-conductor cables twisted together, having a common covering.

The term duplex is used by some manufacturers to describe twin cable.

14. Twin Cable: Two insulated single-conductor cables laid parallel, having a common covering.

15. Duplex Wire: Two small insulated conductors twisted together, having a common covering.

16. Twin Wire: Two small insulated conductors laid parallel, having a common covering.

17. Triplex Cable: Three insulated single-conductor caples twisted together, having a common covering.

A. AMES, Kerite Ins. Wire & Cable Co.
W. S. CLARK, General Electrical Co.
A. L. CRATER, N. Y. C. & H. R. R. R. Co.
W. A. DEL MAR, N. Y. C. & H. R. R. R. Co.
R. W. KRASS, New York Edison Co.
W. I. MIDDLETON, Simplex Wire & Cable. Co.
F. J. WHITE, Okonite Co.

Specifications for Electric Wire Crossings for Potentials Above 100 Volts

1. These specifications define the minimum requirements and describe the type of construction desired by the A., B. & C. Railroad Company in the erection and maintenance of electric transmission, lighting and power lines of other companies at points where such lines cross the tracks, right-of-way or property of the railroad company.

2. The Company installing a crossing underground, overhead or beneath a bridge shall, on the completion of the work, promptly replace and restore the property and site to its original condition, and shall remove all plant and rubbish incident to the construction of the crossing.

Underground Crossings.

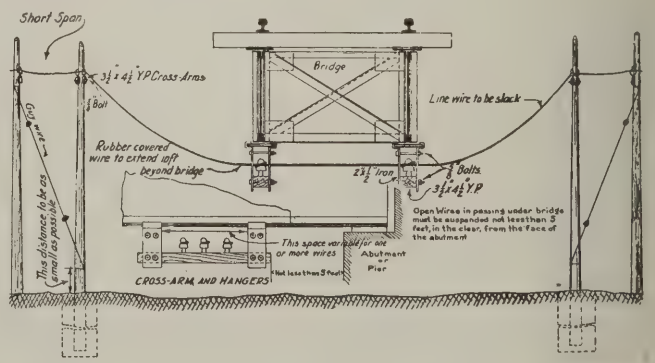
3. Wires, or cables, shall be carried in some suitable form of vitrified earthenware, treated fiber, creosoted pump stock, or iron pipe conduit of a size sufficient to permit the wires, or cables, to be readily drawn in, and shall terminate in manholes, pull-boxes, or terminals, located, if possible, outside the Railroad Company's property.

4. The top of the conduit shall be located at a depth of not less than four feet (4′) below the base of rail nor less than two feet six inches (2′ 6″) below the surface of the ground at the lowest point of crossing of the Railroad Company's property, wherever possible. Conduit shall be laid with a uniform slope of not less than one-eighth inch (⅛″) to the foot to drain away from the Railroad Company's property.

5. Conduit shall be laid on a footing of concrete not less than three inches (3″) thick, and the sides shall be protected by concrete not less than three inches (3″) thick. Over the top shall be laid a covering of concrete not less than three inches (3″) thick.

Underbridge Crossings.

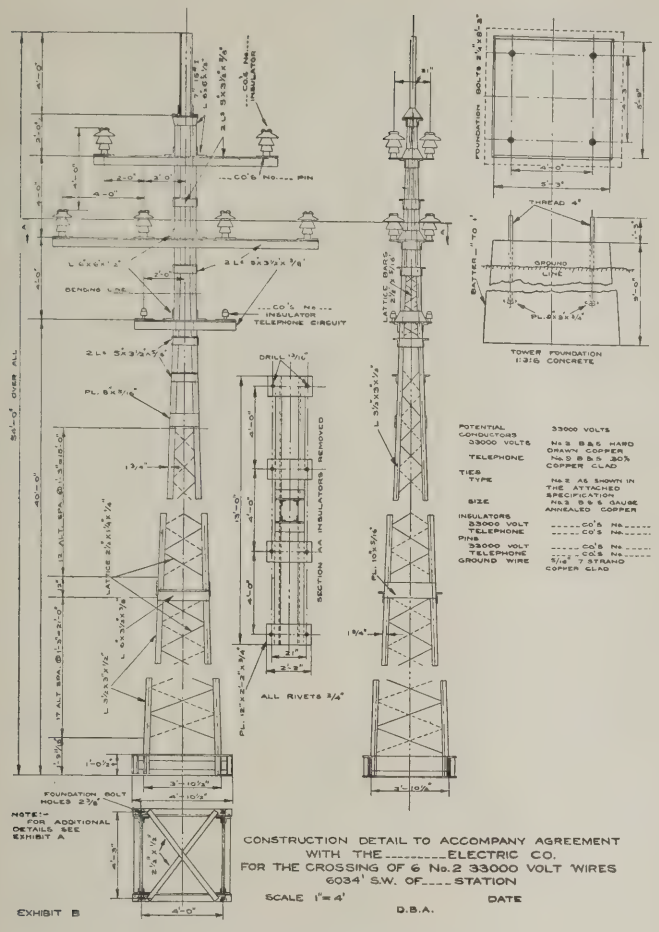
6. Wires, or cables, may be supported beneath bridges, in a grounded iron or lead pipe conduit, supported at suitable intervals, and extending three feet (3′) beyond the bridge structure.


Short Span
Bridge
Line wire to be slack
Rubber covered wire to extend 3ft beyond bridge
Open wires in passing under bridge must be suspended not less than 3 feet, in the clear, from the face of the abutment
This space variable for one or more wires
Abutment or Pier
CROSS-ARM AND HANGERS
Not less than 3 feet

Standard Open Wire Suspension from Railroad Bridge.

7. Conductors carrying a potential in excess of 5000 volts constant potential or 10,000 volts constant current shall not be installed beneath steel bridges in open construction, unless the clearance between any portion of the bridge structure and the wires or cables shall be not less than eight feet (8′).

8. Where wires or cables pass beneath bridges and are attached thereto, the construction of the supports adja-



33,000 Volt Crossing Construction.

cent to the bridge shall conform to that portion of these specifications following relating to overhead crossing construction.

9. Wires, or cables, supported in open construction or in cables shall be supported not less than five feet (5′) in the clear from the face of the abutment.

10. The minimum clearance between wires or cables and any portion of the bridge shall generally be one foot (1′), but in no case less than six inches (6″).

11. The separation of conductors at the bridge attachments shall not be less than nine inches (9″).

12. Spans attached to and supported beneath bridges shall not exceed fifty feet (50′) between the supports.

13. Insulators shall conform to Paragraphs Nos. 38 and 40.

14. Attachment of conductors to insulators shall conform to Paragraphs Nos. 47, 48, 49 and 50.

15. Pins shall conform to Paragraph No. 52.

16. Pin supports shall not be less than three and one-half inches by four and one-half inches (3½″ x 4½″) in section and shall be supported as shown on A. B. C. Railroad standard plan No. ——, or other method approved by the Railroad Company.

17. The pin supports attached to the bridge shall be plainly marked by a sign, reading "DANGER, DO NOT TOUCH" and the name or initials of the owning Company.

Overhead Crossings.

18. Poles, or towers, shall preferably be located outside the Railroad Company's property, except in unusual cases or to secure a shorter crossing span.

19. Long crossing spans shall be avoided, and wherever possible, shall not exceed one hundred feet (100′) in length.

20. Wherever practicable, the adjoining spans shall be of a length not in excess of one and one-half times the length of the crossing span, and it is desirable that all spans be approximately the same length.

21. It is desirable that the crossing span be at approximately right angles to the Railroad Company's tracks, but it is more important that the crossing and adjoining poles or towers be located in a straight line when this may be done without installing an unusually long crossing span.

22. The poles, or towers, shall be located as far as possible from inflammable material or structures.

23. The wires, or cables, shall cross over telegraph, telephone and similar wires wherever practicable.

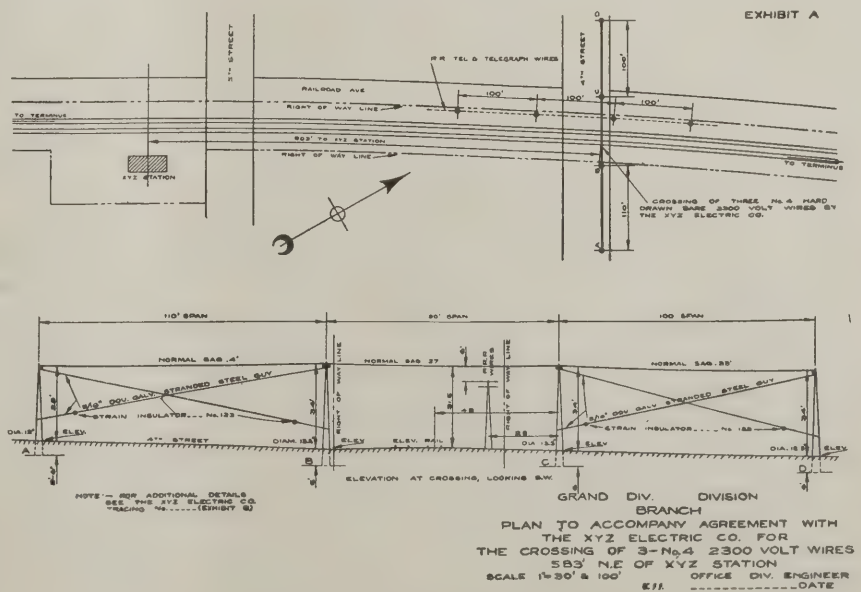
24. Cradles, or overhead bridges, shall not be used beneath the crossing wires or cables; but, in cases where the crossing wires or cables cross beneath the Railroad Company's telephone, telegraph or other similar wires, a protection of adequate strength and proper design may be required between the two sets of crossing wires or cables.

Clearances.

25. Unless physical conditions or municipal requirements prevent, the side clearance shall not be less than twelve feet (12′) from the nearest track rail, except that at sidings a clearance of not less than seven feet (7′) may be allowed. At loading sidings sufficient space shall be left for a driveway.

26. The desired vertical clearance above top of rail, under the most unfavorable conditions of temperature and loading, is thirty feet (30′), but in no case shall this clearance be less than twenty-five feet (25′), except trolley contact wires which may be supported at a height of not less than twenty-two feet (22′).

27. The clearance between the crossing wires, or cables, and any existing wires, under the most unfavorable conditions of temperature and loading, shall preferably be eight feet (8′). For potentials greater than 7,000 volts and less than 27,000 volts, the minimum



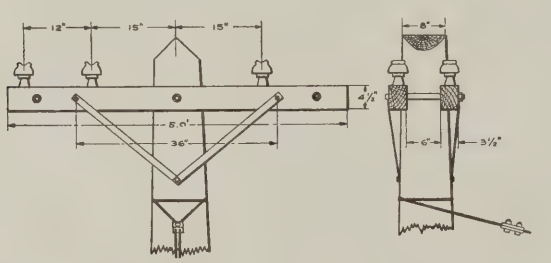
2,300 Volt Crossing Location Plan.

clearance between the crossing wires, or cables, from any existing wires shall not be less than six feet (6′). For potentials less than 7,000 volts the clearance may be less than eight feet (8′), but not less than that shown in the following table:

Distance between the nearest crossing support and the point of crossing of other wires.	*Clearance*
Not exceeding 10 feet	4 feet
Not exceeding 20 feet	5 feet
Not exceeding 30 feet	6 feet
Not exceeding 40 feet	7 feet

28. The minimum separation of conductors, supported on pin type insulators in the same horizontal plane, shall be one inch (1″) for each twenty feet (20′) of span and one inch (1″) additional for each foot, or portion thereof, of sag, but in no case shall the separation be less than that shown in the following table:

Line Voltage	*Separation*
Exceeding 100 but not exceeding 7,000	12″
Exceeding 7,000 but not exceeding 14,000	20″
Exceeding 14,000 but not exceeding 27,000	30″
Exceeding 27,000 but not exceeding 35,000	36″
Exceeding 35,000 but not exceeding 47,000	45″
Exceeding 47,000 but not exceeding 70,000	60″



2,300 Volt Crossing Construction Detail.

29. When conductors are supported by suspension or disc type insulators, the separation specified in Paragraph No. 28 shall be increased by three-fourths (¾) of the distance from the lowest fixed supporting point of the insulators to the conductors; or two (2) insulators shall be so placed as to prevent swinging of the conductors.

30. For conductors supported on pin type insulators, the clearance in any direction between the conductors nearest the pole or tower and the pole or tower shall not be less than that shown in the following table:

Line Voltage	*Clearance*
Not exceeding 7,000	6″
Exceeding 7,000 but not exceeding 14,000	9″
Exceeding 14,000 but not exceeding 27,000	15″
Exceeding 27,000 but not exceeding 35,000	18″
Exceeding 35,000 but not exceeding 47,000	21″
Exceeding 47,000 but not exceeding 70,000	24″

31. For conductors supported by suspension or disc type insulators, the pole or tower clearance specified in Paragraph No. 30 shall be increased by three-fourths (¾) of the distance from the lowest fixed supporting point of the insulator to the conductor; or two (2) insulators shall be so placed as to prevent swinging of the conductor.

Conductors.

32. The conductors shall not be spliced in the crossing span nor in the adjoining span on either side.

33. Taps shall not be connected to any conductor in the crossing span.

34. The conductors shall be of copper, aluminum, or other non-corrodible material, except that in exceptionally long spans, where the required mechanical strength cannot be obtained with the above materials, galvanized or copper-clad steel strand may be used.

35. Conductors may be stranded but preferably solid, including No. 4/0 B. & S. gauge and smaller wires. Conductors larger than No. 4/0 B. & S. gauge shall be stranded. Aluminum conductors shall be stranded. Conductors may be insulated, but it is preferable that they be bare.

36. The minimum sizes of conductors shall be as follows:

No. 6 B. & S. gauge copper for potentials not exceeding 5,000 volts.

No. 4 B. & S. gauge copper for potentials exceeding 5,000 volts, except that No. 6 B. & S. gauge copper will be allowed for constant current circuits.

No. 1 B. & S. gauge aluminum for all potentials.

When telephone wires are carried on the same supports with the lighting or power conductors, the minimum size shall not be less than that shown in the following table:

Hard-Drawn Copper	*Spans*
No. 10 B. & S. gauge	Not exceeding 100 feet
No. 9 B. & S. gauge	Not exceeding 120 feet
No. 8 B. & S. gauge	Not exceeding 150 feet
No. 6 B. & S. gauge	Exceeding 150 feet.

NOTE.—Copper or copper-clad wire of an equivalent strength may be substituted for any of the above sizes.

For spans exceeding 150 feet the requirements of conductor spacing and supports shall apply to telephone wires.

Telephone wires shall be tied by the Railroad Standard method known as the over and under tie and in no case are the wires to be tied so tight as to injure the line wire.

37. The normal mechanical tension in each separate conductor preferably shall be the same in the crossing span and adjoining span on each side, and the total mechanical tension on each side of the crossing or adjoining poles shall be the same; or such poles shall be self-supporting, or guyed in accordance with Paragraph No. 75.

Insulators.

38. All line insulators for potentials of 2,000 or more volts shall be of porcelain. Insulators for line potentials of less than 2,000 volts may be of porcelain, glass or other approved material.

39. Insulators shall be double on the crossing-poles, or towers, for all potentials.

40. Insulators for line potentials of less than 9,000 volts shall not puncture nor flash over at four (4) times the normal working voltage, under a precipitation of one-fifth inch (1/5″) of water per minute, at an inclination of forty-five degrees (45°) to the axis of the insulator.

41. Each separate part of a built up insulator for line

potentials greater than 9,000 volts shall withstand a dry flash over test of that part for five (5) consecutive minutes.

42. Each assembled and cemented line insulator shall withstand its dry flash over test of five (5) consecutive minutes. The dry flash over test shall not be less than that shown in the following table:

Line Voltage	*Test Voltage*
Exceeding 9,000 but not exceeding 14,000.	65,000
Exceeding 14,000 but not exceeding 27,000.	100,000
Exceeding 27,000 but not exceeding 35,000.	125,000
Exceeding 35,000 but not exceeding 47,000.	150,000
Exceeding 47,000 but not exceeding 60,000.	180,000
Exceeding 60,000.....	Three times line voltage

43. Each assembled and cemented line insulator shall withstand a wet flash over test under a precipitation of one-fifth inch (1/5″) of water per minute at an inclination of forty-five degrees (45°) to the axis of the insulator. The wet flash over test shall not be less than that shown in the following table:

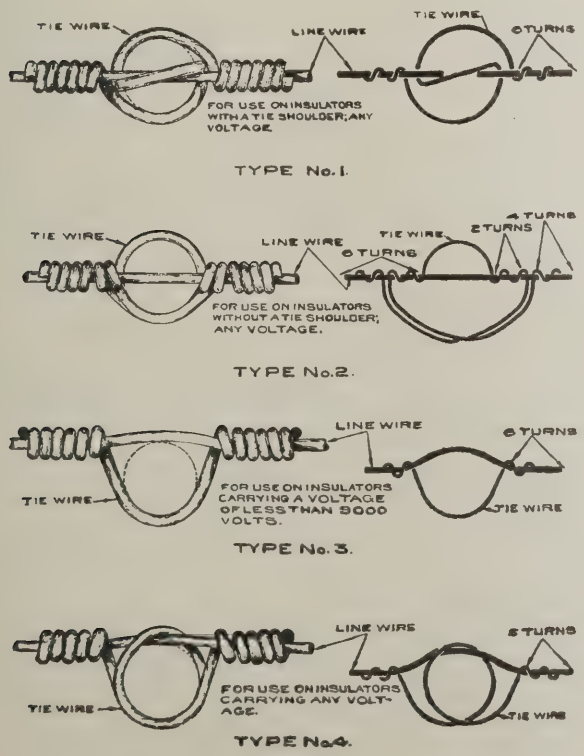
Line Voltage	*Test Voltage*
Exceeding 9,000 but not exceeding 14,000.	40,000
Exceeding 14,000 but not exceeding 27,000.	60,000
Exceeding 27,000 but not exceeding 35,000.	80,000
Exceeding 35,000 but not exceeding 47,000.	100,000
Exceeding 47,000 but not exceeding 60,000.	120,000
Exceeding 60,000.....	Twice line voltage

44. Test potentials above 35,000 volts shall be determined by the A. I. E. E. standard spark gap. Test potentials less than 35,000 volts shall be determined by transformer ratio.

45. Strain insulators installed in guys shall have an ultimate strength according to their construction:

(*a*) Strain insulators, constructed so that the mechanical tension members will interlock in case of failure, shall have an ultimate strength of not less than the breaking strength of the guy in which installed.

(*b*) Strain insulators, constructed so that the mechanical tension members will not interlock in case of failure, shall have an ultimate strength not less than one and one-half (1½) times the breaking strength of the guy in which installed.



Ties for Top and Side Groove Pin Type Insulators.

46. Strain insulators, installed in guys in accordance with Paragraph No. 76, shall not puncture nor flash over under a precipitation of one-fifth inch (1/5″) of water per minute, when tested at twice the maximum line potential carried by the guyed pole; or at twice the maximum line potential of any other line not exceeding 9,000 volts in the immediate vicinity of the guyed pole.

Ties.

47. Crossing wires supported on pin type insulators shall be secured to the insulators by wire ties. Under unusual conditions of any nature crossing wires shall be attached to the supporting structures in an approved manner.

48. Ties shall be solid, annealed wire of the same gauge and material as the conductors up to and including No. 2 B. & S. gauge. In cases where it is desired to use a smaller tie, this will be permitted provided a continuous length of wire is used to make a sufficient number of turns around the conductor and insulator as will be equivalent to the conductor up to and including No. 2 B. & S. gauge.

49. Conductors larger than No. 2 B. & S. gauge shall be tied with No. 2 B. & S. gauge wire, or equivalent in accordance with Paragraph No. 48.

50. Ties shall be of an approved form. Types as shown herein being acceptable.

Pins.

51. Pins shall be double on each of the crossing poles or towers.

52. Locust pins supporting wires not exceeding No. 2 B. & S. gauge, carrying potentials not exceeding 9,000 volts in spans not exceeding one hundred and fifty feet (150′) will be approved. Metal pins will be required for wires larger than No. 2 B. & S. gauge, potentials in excess of 9,000 volts or spans greater than one hundred and fifty feet (150′).

Cross-Arms.

53. Cross-arms shall be double on the crossing poles or towers.

54. Wood cross-arms for potentials not exceeding 27,000 volts under favorable conditions may be approved.

55. Wood cross-arms shall not be less than 3¼″ x 4¼″ in section, and shall be held together with properly fitted spacing blocks or bolts, placed immediately adjoining the outside pins. Wood cross-arms shall be properly fitted in gains and held in place by not less than one ⅜″ through bolt. Both arms to be fitted with galvanized iron or steel braces not less than $1\frac{7}{32}$″ x $\frac{7}{32}$″ section or equivalent iron or steel section; which shall be attached to the cross-arms by not less than ⅜″ through bolts and to the pole with not less than ½″ through bolts, or ½″ x 4½″ lag screws.

56. All cross-arms shall be designed so that the maximum stress shall not exceed that allowed for the several materials as specified in Paragraph No. 93, when loaded as specified in Paragraphs Nos. 87, 88, 89, 90 and 91, combined with the unbalanced stress due to one wire broken and loaded in the adjoining span to the ultimate strength of the wire up to and including No. 2 B. & S. gauge wire. This unbalanced load to be considered as applied with a lever arm equal to the conductor spacing. In the case of cross-arms supporting two (2) or less conductors the above unbalanced loading shall be considered as applied with a lever arm equal to the distance

from the outside conductor to the nearest cross-arm support.

Poles or Towers.

57. Wooden poles shall be of selected timber, reasonably straight, peeled, free from defects which would decrease their strength or durability; not less than eight inches (8″) minimum diameter at the top and meeting the requirements specified in Paragraphs Nos. 92 and 93.

58. Steel for towers shall conform to the Manufacturer's Standard specifications.

59. The design and workmanship shall conform to the requirements of first class practice.

60. The form of the frame shall be such that the stresses may be computed or the strength determined by actual test.

61. The sections used shall permit of inspection, cleaning and painting and shall be free from pockets in which water or dirt can collect.

62. The length of a main compression member shall not be greater than one hundred and eighty (180) times its least radius of gyration. The length of a secondary compression member shall not exceed two hundred and twenty (220) times its least radius of gyration.

63. The minimum thickness of members in galvanized structures shall be one-fourth inch (¼″) for main members and one-eighth inch (⅛″) for secondary members. The minimum thickness for painted material shall be one-fourth inch (¼″).

64. Portland cement alone shall be used for concrete poles, towers or foundations.

65. Sand shall be clean, sharp, and coarse, but preferably of grains varying in size, well screened and free from pebbles, loam, clay, dust, mica or other impurities.

66. (*a*) Crushed stone shall be hard, clean, trap rock, free from sticks, earthy or clayey matter and rotten stone. It shall be freed from dust by screening and of a size which may be readily placed around the reinforcement.

(*b*) Gravel shall be composed of clean pebbles of hard and durable stones, free from clay and other impurities, except sand, and of a size which may be readily placed around the reinforcement.

67. The mixture shall be such as to give a concrete without appreciable voids and having a compressive strength of not less than two thousand pounds per square inch when tested in eight inch cubes at twenty-eight (28) days.

Pole Settings.

68. Poles thirty feet (30′) and under shall be set five feet six inches (5′ 6″) in the ground.

69. For poles longer than thirty feet (30′) the setting specified in Paragraph No. 68 shall be increased six inches (6″) for each additional five feet (5′) in total length, up to and including an eight foot (8′) setting.

70. When poles are located in swampy ground, the sides of banks or locations subject to washouts, the setting specified in Paragraphs Nos. 68 and 69 shall be increased, or settings shall be protected by stone, timber cribbing or rip-rap.

Foundations.

71. The foundations for steel or concrete poles or towers shall be designed with a factor of safety of two (2) to prevent overturning under conditions as specified in Paragraph No. 92.

72. In estimating, the weight of concrete shall be taken as one hundred and forty (140) pounds per cubic foot. In good ground the weight of earth (calculated at thirty degrees (30°) from the vertical) shall be taken as one hundred (100) pounds per cubic foot. In swampy ground special measures shall be taken to prevent uplift or overturning.

73. The top of concrete foundations, or casings for steel, shall in no case be less than six inches (6″) above the ground line. In locations subject to high water, foundations or casings shall extend to the same elevation as the base of the Railroad Company's rail, or shall extend one foot (1′) above extreme high water.

Guys.

74. No guy shall be less than five-sixteenth inch (5/16″) nominal diameter, double-galvanized stranded steel of a tensile strength not less than forty-five hundred (4500) pounds. Copper-clad steel strand of an equivalent strength will be approved.

75. All wooden crossing poles, supporting four (4) or more No. 6 B. & S. gauge wires or their equivalent in section, shall be head guyed away from the Railroad Company's property, and shall be sufficiently guyed at other points to take strain due to change in alignment or change in mechanical tension.

76. Guys attached to wooden poles or to wood stubs and having in their vicinity potentials exceeding 500 volts, but not exceeding 9,000 volts, whether carried on the guyed poles or otherwise, shall be provided with at least one (1) strain insulator, which shall meet the requirements of Paragraphs Nos. 45 and 46. This insulator shall be placed not less than eight feet (8′) vertically above the ground line.

77. Guys to the ground shall connect to a galvanized anchor rod extending at least one foot (1′) above the ground level. The details of the anchorage shall be definitely shown on the plans.

Protective Coatings.

78. It is desired that all wooden pole butts be treated by the open tank method with creosote which will meet the requirements of Grade 1, as specified by the American Railway Engineering Association.

79. All structural steel shall be thoroughly cleaned at the shop and be galvanized or given one (1) coat of approved paint.

80. All contact surfaces shall be given one (1) coat of paint before assembling. All painted structural steel shall be given two (2) field coats of an approved paint. The surfaces of steel shall be thoroughly cleaned of all dirt, grease, scale, etc., before painting. No painting shall be done in rainy or freezing weather and no coat of paint shall be applied until the previous coat of paint shall have hardened.

81. Galvanized material shall be in accordance with the specifications for galvanized iron and steel of the National Electric Light Association or shall be sherardized, and it is desirable that bolts, washers, nuts, metal pins, braces, guys, clamps and other metal parts be so treated.

Lightning Protection Wires.

82. Lightning protection wires supported above the crossing conductors shall not be less than No. 4 B. & S. gauge copper or copper-clad wire. Five-sixteenth inch (5/16″) nominal diameter, or larger steel strand, double-galvanized and having a breaking strength of not less than forty-five hundred (4500) pounds will be approved. When such wires are installed on any other than a thoroughly grounded steel structure they shall be permanently connected to the ground at each of the crossing poles, or towers, with a copper wire preferably of No. 2 B. & S. gauge, but not less than No. 4 B. & S. gauge or equivalent copper section. The course of this ground connection shall be as straight as possible.

83. Each of the crossing poles or towers shall be clearly marked by stencil or metal tags with the name or initials of the owning Company.

Drawings.

84. The Company desiring a wire crossing shall furnish on linen a tracing showing the complete details of the construction contemplated. The over all dimensions of tracing shall be eight and one-half inches by fourteen inches ($8\frac{1}{2}'' \times 14''$) or multiples thereof.

In lieu of the above requested tracings, blue prints as required shall be furnished.

NOTE.—The information desired includes the following: The location of the crossing and the plan of the crossing; size of conductors, the normal sag of the conductors, and their respective potentials and spacing; the manufacturer's name, type or form number of insulators and pins; type of ties, dimensions and material of cross-arms; size, height and setting of poles, or complete details of towers; and size and location of guys.

Approval.

85. All work shall be installed in accordance with these specifications and detail drawings approved by the General Superintendent Motive Power or other authorized representative of the Railroad Company.

86. The meaning and intent of these specifications shall be interpreted by the Railroad Company.

Loads.

87. In the design of construction allowance shall be made for both dead and live loads.

88. The dead load consisting of the weight of the materials and the live load of ice, wind and temperature loads.

89. The ice load shall be taken as a coating of ice one-half inch ($\frac{1}{2}''$) thick all around the exposed mem-

APPENDIX A.

TABLE I.

STEEL WIRE—STRANDED—GALVANIZED.

Diameter	Number and Gauge of Wires	Area Square Inches	Guy Wire	Ultimate Strength in Pounds: Siemens-Martin 75,000 lbs. per Square Inch	Ultimate Strength in Pounds: High Tension 125,000 lbs. per Square Inch	Ultimate Strength in Pounds: Ex. High Tension 187,000 lbs. per Square Inch	Load per Linear Foot, Vertical: Dead	Load per Linear Foot, Vertical: Dead + One-half Inch Ice	Load per Linear Foot Horizontal in lbs. 8.0 lbs. per Square Foot One-half Inch Ice	Maximum Load per Linear Foot Plane of Resultant in lbs.	E A / E = 29,000,000 lbs. per Square Inch
$\frac{5}{8}''$	7–5	0.2356		19,000	25,000	42,000			1.083		6,832,400
$\frac{9}{16}''$	7–6½	0.1922		14,500	21,100	34,500	0.668	1.329	1.042		5,573,800
$\frac{1}{2}''$	7–8	0.1443	8,500	11,000	18,000	27,000	0.510	1.132	1.000	1.510	4,184,700
$\frac{7}{16}''$	7–9	0.1204	6,500	9,000	15,000	22,500	0.415	0.998	0.958	1.383	3,491,600
$\frac{3}{8}''$	7–11	0.0832	5,000	6,800	10,500	17,250	0.295	0.839	0.917	1.243	2,412,800
$\frac{5}{16}''$	7–12	0.0606	3,800	4,860	8,100	12,100	0.210	0.715	0.875	1.130	1,757,400

PROPERTIES OF WIRE MATERIAL.

	Ultimate Strength Pounds per Square Inch	Elastic Limit Pounds per Square Inch	Mod. Elasticity = E Pounds per Square Inch	Coefficient Expansion
Copper, solid, soft-drawn	32–34,000	28,000	12,000,000	0.0000096
" " hard-drawn	50–55–57–60,000	30–32–34–35,000	16,000,000	0.0000096
" stranded, soft-drawn	34,000	28,000	12,000,000	0.0000096
" " hard-drawn	60,000	35,000	16,000,000	0.0000096
Aluminum, stranded	23–24,000	14,000	9,000,000	0.0000128
Steel, stranded, Siemens-Martin	75,000		29,000,000	0.0000064
" " High-tension	125,000		29,000,000	0.0000064
" " Extra High-tension	187,000		29,000,000	0.0000064

TABLE II.

COPPER WIRE—STRANDED.

Gauge B. & S.	Diameter Inches	Area Square Inches	Hard Drawn: Ultimate Tension Pounds	Hard Drawn: Allowable Tension Pounds	Soft Drawn: Ultimate Tension Pounds	Soft Drawn: Allowable Tension Pounds	Load per Linear Foot, Vertical, in Pounds: Dead	Load per Linear Foot, Vertical, in Pounds: Dead + One-half Inch Ice	Load per Linear Foot Horizontal in lbs. 8.0 lbs. per Square Foot One-half Inch Ice	Maximum Load per Linear Foot Plane of Resultant in Pounds	E A / E = 16,000,000	E A / E = 12,000,000
500,000	0.819	0.3924	23,540	11,750	13,340	6,650	1.525	2.345	1.213	2.640	6,278,400	4,708,800
450,000	0.770	0.3535	21,210	10,600	12,020	6,000	1.373	2.163	1.180	2.464	5,636,800	4,242,000
400,000	0.728	0.3141	18,860	9,400	10,680	5,350	1.220	1.984	1.152	2.294	5,025,600	3,769,200
350,000	0.679	0.2750	16,500	8,250	9,350	4,650	1.068	1.801	1.119	2.120	4,400,000	3,300,000
300,000	0.630	0.2360	14,160	7,100	8,025	4,000	0.915	1.618	1.087	1.949	3,776,000	2,832,000
250,000	0.590	0.1965	11,790	5,900	6,680	3,350	0.762	1.440	1.060	1.788	3,144,000	2,358,000

TABLE III.

COPPER WIRE—SOLID.

0000	0.460	0.1662	8,310	4,150	5,650	2,800	0.641	1.238	0.973	1.575	2,659,200	1,994,400
000	0.410	0.1318	6,590	3,300	4,480	2,250	0.509	1.074	0.940	1.427	2,108,800	1,581,600
00	0.365	0.1045	5,220	2,600	3,555	1,750	0.403	0.940	0.910	1.309	1,672,000	1,254,000
0	0.325	0.0829	4,560	2,300	2,820	1,400	0.320	0.833	0.883	1.214	1,326,400	994,800
1	0.289	0.0657	3,740	1,850	2,235	1,100	0.253	0.744	0.860	1.137	1,051,200	788,400
2	0.258	0.0521	3,120	1,550	1,770	900	0.202	0.673	0.838	1.075	833,600	625,200
4	0.204	0.0328	1,960	1,000	1,115	550	0.126	0.564	0.803	0.981	524,800	393,600
6	0.162	0.0206	1,240	600	700	350	0.079	0.491	0.775	0.917	329,600	247,200

TABLE IV.

COPPER WIRE—SOLID, TRIPLE-BRAID WEATHER-PROOFING.

0000	0.640	0.1662	8,310	4,150	5,650	2.800	0.767	1.476	1.093	1.837	2,659,200	1,994,400
000	0.593	0.1318	6,590	3,300	4,480	2.250	0.629	1.309	1.062	1.686	2,108,800	1,581,600
00	0.515	0.1045	5,220	2,600	3,555	1.750	0.502	1.133	1.010	1.518	1,672,000	1,254,000
0	0.500	0.0829	4,560	2,300	2,820	1,400	0.407	1.029	1.000	1.434	1,326,400	994,800
1	0.453	0.0657	3,740	1,850	2,235	1,100	0.316	0.909	0.968	1.328	1,051,200	788,400
2	0.437	0.0521	3,120	1,550	1,770	900	0.260	0.843	0.958	1.276	833,600	625,200
4	0.359	0.0328	1,960	1,000	1,115	550	0.164	0.698	0.906	1.143	524,800	393,600
6	0.328	0.0206	1,240	600	700	350	0.112	0.627	0.885	1.084	329,600	247,200

ber, taken at fifty-seven (57) pounds per cubic foot (0.033 pounds per cubic inch).

90. The wind load shall be taken as eight (8) pounds per square foot of projected area of ice-covered wires or cable, and at thirteen (13) pounds per square foot on all other ice-covered surfaces.

91. The temperature load shall be taken as the stresses produced by a change of temperature to minus twenty degrees (20°) Fahrenheit. In the determination of clearances and in erection, provision shall be made for a change in temperature of sixty degrees (60°) Fahrenheit above and eighty degrees (80°) Fahrenheit below a normal temperature of sixty degrees (60°) Fahrenheit.

Conditions of Loading.

92. Wires, or cables, shall be considered as loaded in accordance with Paragraphs Nos. 87, 88, 89, 90 and 91. Insulators and pins shall be considered as subjected to an unbalanced stress in the conductor equal to the ultimate strength of the conductor supported up to and including No. 2 B. & S. gauge wire. Cross-arms shall be considered as loaded as specified in Paragraph No. 56. Poles, or towers, and foundations shall be considered loaded as specified in Paragraphs Nos. 87, 88, 89 and 90, combined with the unbalanced stress due to one conductor per cross-arm or direct attachment, broken and loaded in the crossing span to its ultimate strength up to and including No. 2 B. & S. gauge wire.

93. Under the conditions as specified in Paragraph No. 92, the maximum stress shall not exceed one-half (½) of the ultimate strength of the insulators and pins; nor shall the maximum fiber stress in wires or cables, cross-arms, poles or structures exceed the following allowable stresses for the several materials:

Structural Steel;

Tension (net section) . 18,000 lbs. per sq. in.
Shear . . . . . 14,000 lbs. per sq. in.
Compression . . . . . 18,000—60 L/R lbs. per sq. in.

Rivets, Pins;

Shear . . . . . 10,000 lbs. per sq. in.
Bearing . . . . . 20,000 lbs. per sq. in.
Bending . . . . . 20,000 lbs. per sq. in.

Bolts;

Shear . . . . . 8,500 lbs. per sq. in.
Bearing . . . . . 17,000 lbs. per sq. in.
Bending . . . . . 17,000 lbs. per sq. in.

Concrete;

Tension 0.0
Compression . . . . . 1,000 lbs. per sq. in.
Ratio modulus of elasticity of steel to concrete 15 to 1.

Wires and Cables	*B. & S. Gauge*	*Lbs. per sq. in.*
Copper...Hard drawn...	Solid...4/0, 3/0, 2/0	25,000
Copper...Hard drawn...	Solid... 1/0	27,500
Copper...Hard drawn...	Solid... 1	28,500
Copper...Hard drawn...	Solid... 2, 4, 6	30,000
Copper...Soft drawn...	Solid.....	17,000
Copper...Hard drawn...	Stranded.....	30,000
Copper...Soft drawn...	Stranded.....	17,000
Aluminum Hard drawn...	Stranded Under 4/0	12,000
Aluminum Hard drawn...	Stranded 4/0 and over	11,500

Untreated Timber	*Bending lbs. per sq. in.*	*Compression lbs. per sq. in.*
Eastern white cedar.....	600.....	600
Cypress	800.....	800
Chestnut	850.....	850
Long leaf yellow pine....	1100.....	1100

(*Table Continued on P.* 183.)

APPENDIX B.

MINIMUM SAGS FOR COVERED SOLID SOFT COPPER WIRE.

	Temperature F	Span in Feet: 60	80	100	120	140	160
		Sags in Inches					
No. 6 B. & S.	-20	7	21	38	66	102	
	0	9	22	40	72	102	
	20	10	24	41	72	102	
	40	12	25	42	72	108	
	60	13	26	43	72	108	
	80	14	27	45	72	108	
	100	15	29	46	78	108	
	120	17	30	47	78	108	

	Temperature F	Span in Feet: 60	80	100	120	140	160
		Sags in Inches					
No. 4 B. & S.	-20	3	7	17	35	60	114
	0	3	8	19	37	60	120
	20	4	10	21	39	60	120
	40	5	12	23	41	66	120
	60	6	14	25	43	66	120
	80	8	16	27	45	66	126
	100	10	17	29	46	72	126
	120	11	19	30	48	72	126

	Temperature F	Span in Feet: 60	80	100	120	140	160
		Sags in Inches					
No 2 B & S	-20	3	5	9	17	29	66
	0	3	6	11	20	33	72
	20	3	7	11	22	36	72
	40	3	8	13	25	39	72
	60	4	9	16	28	43	78
	80	4	10	17	30	46	84
	100	5	11	19	33	49	84
	120	5	12	21	36	52	84

	Temperature F	Span in Feet: 80	100	120	140	160	180
		Sags in Inches					
No. 0 B. & S.	-20	3	5	11	17	36	72
	0	3	7	13	20	36	72
	20	4	8	14	23	36	78
	40	5	9	16	26	42	84
	60	6	10	18	28	48	84
	80	7	11	20	31	54	90
	100	8	13	22	34	54	96
	120	9	14	23	36	60	96

	Temperature F	Span in Feet: 80	100	120	140	160	180
		Sags in Inches					
No. 00 B. & S.	-20	3	3	4	8	12	48
	0	3	3	5	10	18	54
	20	4	4	7	12	24	66
	40	5	5	8	13	24	66
	60	5	5	9	15	24	72
	80	6	6	10	17	24	78
	100	7	7	11	18	30	84
	120	8	8	13	20	30	84

APPENDIX B.

MINIMUM SAGS FOR SOLID HARD-DRAWN BARE COPPER WIRE.

	Temperature F	Span in Feet: 100 or less	125	150	200	250	
		Sags in Inches					
No. 6 B. & S.	-20	3	8	22	66	120	
	0	4	10	26	72	120	
	20	5	13	30	72	126	
	40	6	16	33	72	126	
	60	8	19	36	72	132	
	80	10	22	39	78	132	
	100	13	25	41	84	138	
	120	16	28	44	84	138	

	Temperature F	Span in Feet: 100 or less	125	150	200	250	300
		Sags in Inches					
No 4 B. & S.	-20	3	4	8	25	60	108
	0	3	5	9	29	60	108
	20	3	6	11	33	72	114
	40	4	7	13	38	72	120
	60	4	9	16	42	84	120
	80	5	11	19	46	84	126
	100	7	13	23	50	90	132
	120	9	16	27	54	90	132

	Temperature F	Span in Feet: 100 or less	125	150	200	250	300
		Sags in Inches					
No. 2 B. & S.	-20	2	4	5	12	25	48
	0	3	4	6	14	29	54
	20	3	5	7	16	33	60
	40	3	5	8	19	39	66
	60	4	6	10	23	43	72
	80	4	7	12	27	48	78
	100	5	9	14	31	53	84
	120	7	11	18	35	58	90

	Temperature F	Span in Feet: 100 or less	125	150	200	250	300
		Sags in Inches					
No. 1 B. & S.	-20	2	4	5	10	19	36
	0	3	4	6	11	22	42
	20	3	4	6	13	25	48
	40	3	5	7	15	30	54
	60	4	6	8	18	34	60
	80	4	7	10	21	39	66
	100	5	8	12	25	44	72
	120	6	10	16	30	49	72

APPENDIX B.

MINIMUM SAGS FOR STRANDED HARD-DRAWN BARE COPPER WIRES.

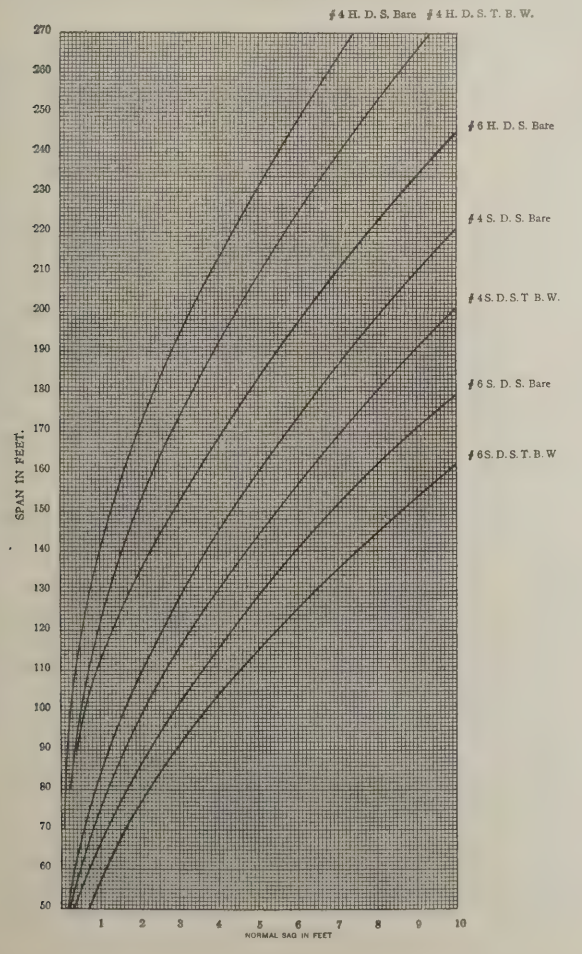
	Temp. F.	Span in Feet: 100 or less	125	150	200	250	300	400
		Sags in Inches						
No. 6 B. & S.	-20	2	3	5	9	16	30	66
	0	3	4	5	10	18	30	78
	20	3	4	6	11	21	36	84
	40	3	5	7	13	24	42	90
	60	3	5	8	15	27	48	96
	80	4	6	9	18	32	54	102
	100	5	7	11	21	37	60	108
	120	6	9	13	25	42	60	114

	Temp. F.	Span in Feet: 100 or less	125	150	200	250	300	400
		Sags in Inches						
No. 2/0 B. & S.	-20	2	3	5	9	14	23	54
	0	2	4	5	10	16	26	60
	20	3	4	6	11	18	29	66
	40	3	4	7	12	21	33	72
	60	3	5	7	14	24	37	78
	80	4	6	9	16	28	43	84
	100	5	7	10	19	32	48	96
	120	6	9	12	23	37	54	102

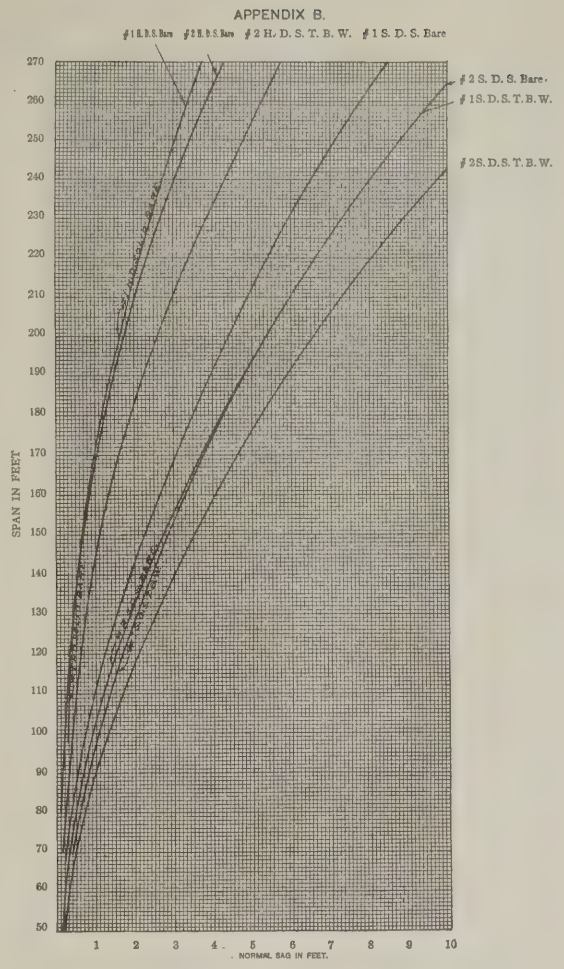
	Temp. F.	Span in Feet: 100 or less	125	150	200	250	300	400
		Sags in Inches						
No. 3/0 B. & S.	-20	2	3	5	8	13	21	48
	0	2	4	5	9	15	23	48
	20	3	4	5	10	17	25	54
	40	3	4	6	12	19	29	60
	60	3	5	7	13	22	33	72
	80	4	6	8	15	25	38	78
	100	4	7	10	18	29	43	84
	120	5	8	12	21	34	49	90

	Temp. F.	Span in Feet: 100 or less	125	150	200	250	300	400
		Sags in Inches						
No. 4/0 B. & S.	-20	2	3	5	8	13	20	42
	0	2	4	5	9	14	22	42
	20	3	4	6	10	16	24	48
	40	3	4	6	11	18	27	54
	60	3	5	7	13	20	31	60
	80	4	6	8	15	24	35	66
	100	4	7	10	17	27	40	72
	120	5	8	12	20	31	46	84

APPENDIX B.



APPENDIX B.



Short leaf yellow pine	950		950
Washington fir	1000		1000
White oak	950		950
Red cedar	700		700

L=length in inches; D=least side, or diameter, in inches.

APPENDIX D

Sags.

The curves of Appendix "B" show the minimum sags for various conductors, which will meet the requirements of Paragraphs Nos. 92 and 93 of the foregoing specification. When there are a number of spans of different lengths, it is impossible to so string the conductors that the normal and the maximum tensions in the conductors will balance in the several spans. In such cases, select a sag for the major crossing or adjoining span which is not less than that shown on the above mentioned curves and make the sags in the other spans proportional to the square of the spans. If we assume the length of the major span to be "L" and the sag "S" with "l" and "s" the corresponding values for some other span, then their values should be in the following proportion: $L^2 : S :: l^2 : s$. The normal tension in the conductors will then balance in the several spans and the maximum tension in the lesser spans will be somewhat less than that in the major span.

Conductor Spacing.

In Paragraph No. 28 it is specified that the minimum separation of conductors supported on pin type insulators shall be one inch (1″) for each twenty feet (20′) of span and one inch (1″) additional for each foot, or portion thereof, of sag; with a minimum limit depending upon the potential carried by the conductors.

The minimum separation depending upon the length

of span and the sag is to be obtained in the following manner: Divide the length of the longest crossing or adjoining span in feet by twenty (20) and to the quotient add one foot for each foot, or fraction thereof, of sag. The result divided by twelve (12) will be the minimum separation of conductors; provided the potential carried by the conductors would not require a greater spacing than that given by the above method.

Cross-Arms.

When double unit cross-arms are connected together at the ends with spacing blocks, bolts or plates, their combined strength is in excess of double the strength of one unit and is less than the strength of two units considered as acting as one unit.

Allowance will be made for this in the following manner:

(*a*) Wood or steel cross-arms, connected together by bolts with spacing nuts and washers, or by bolts with pipe spacers, or similar construction, will be considered as having a strength not in excess of thirty per cent. (30%) of the net section of the two cross-arms considered as a unit.

(*b*) Wood or steel cross-arms, connected together by blocks or plates, bolted or riveted to the cross-arms, will be considered as having a strength not exceeding forty per cent (40%) of the net section of the two cross-arms considered as a unit.

(*c*) Steel cross-arms designed to take shear between the main members will be allowed a factor of strength in accordance with their construction.

Poles.

The strength of wood poles should be considered at the point coincident with the ground line. The stress at this point will be the product of the length, expressed in inches, between the point of resultant loading and the ground line multiplied by the resultant loading, in pounds, and divided by the section modulus, expressed in inches, of the pole at the ground line. This stress should not exceed that allowed in Paragraph No. 93 for the several materials; or the poles should be guyed to withstand the loading specified in Paragraphs Nos. 87, 88, 89, 90 and 91.

Guys.

When poles are not self-supporting and are guyed, the stress in the guy is a function of the relative location of attachment of the guy to the pole and also a function of the angle which the guy makes with the pole.

(*a*) The guy attached to a pole at a point in its length will be stressed in proportion to the distance, in inches, from the point of resultant loading to the ground line multipled by the resultant loading in pounds, and divided by the distance, in inches, from the ground line to the point of attachment.

(*b*) This stress by (*a*) will be increased in inverse proportion to the sine of the angle which the guy makes with the pole.

It follows that the point of attachment of a guy should be as high as possible on the guyed pole, without interfering with the conductors or surrounding objects, and its ground attachment should be at a distance not less than the pole length from the base of the pole wherever possible.

In case where wood poles are not self-supporting and are guyed, the entire load will be considered as taken by the guy.

The load on steel poles, or steel structures, which are not self-supporting will be considered as composed of two parallel forces, one of which being such as to stress the structure to the values as given in Paragraph No. 93, and the remainder will be assumed as taken by the guy; provided that this force does not stress the guy more than one-half of its ultimate strength.

Respectfully submitted.

J. R. Sloan, Chairman.

Report of Committee on Data and Information

Your committee has endeavored to gather some information on the extent to which various electrical devices are employed on railroads at the present time. Letters were sent out to all of the important roads, requesting information as to the number of arc lamps, large tungsten units, and the horse power and type of electric motors in use.

Shop Equipment.

We regret to advise that only a small number replied to the letters sent out by your committee. However, by referring to Table No. 1, it will be noted that there seems to be a general tendency to replace arc lamps and small incandescents with large tungsten lamps. This is certainly a step in the right direction toward increased efficiency and decreased installation cost and maintenance expense.

It will also be noted that on the 22 roads reported the number of A. C. motors for railway shop work exceeds the number of D. C. motors by 8,877 h. p. The Canadian Pacific Railway, the largest users of electric power in railway shops in the country, except the Pennsylvania Railroad, use A. C. current exclusively. On the other hand, our friends in England, the Great Western Railroad, employ direct current power apparatus exclusively.

From these figures, although we have no definite information as to the equipment in use in previous years, it is evident that the use of A. C. current and machinery

NAME OF RY CO	NO OF PASS CARS: ELECTRIC LIGHT ONLY	OIL LIGHT ONLY	GAS ONLY	COMBINATION WITH ELECTRIC LIGHT	STRAIGHT STORAGE: NO OF CARS	VOLTS	HEAD END LIGHTED: NO OF CARS	VOLTS	AXLE GENERATOR DRIVE: NO OF CARS	VOLTS	BELT END TYPE GENERATOR: NO OF CARS	VOLTS	LEAD BATTERIES: PLANTE PLATE NO OF CELLS	PASTED PLATE NO OF CELLS	EDISON BATTERY CELLS NO	RENTED CARS	REMARKS
PULLMAN CO	5522	34	1258		131	60	425	60	4555 251	30 60	4	60	82136		0		
L V RY CO	261	65	137						249	30			2174		76	44	PULLMAN
L S & M C RY CO	103								64 38	30 60			3847	256	50		
ST L & S F RY	231	190	335		8	30			231	30			7684			22	PULLMAN
CENTRAL OF GEORGIA	12	110	134						12	30			384		250		
C R I & P RY	341								8 332	60 30			5808		125		
C B & Q RY	108	527	39	613	6	60	711	60	4	30	17 51	110 60	2772				
C & N W RY	20	540	450	560			200	60	60	30 60	25	60	2500		25	50	PULLMAN
B & O RY	123	474	638		26	60	49	60	22 26	60 32	11	60	3025		100		
AT & S F RY	55	330	216						418	32			7392		16		2 MOTORS & 1 GAS ENGINE PER CAR
GREAT WESTERN OF ENGLAND	568						98	22	470	22			546				
M ST P & S S M RY	56	246	62						62	30			1070				
I C RY CO	228	518	610	8	60				220	30			1900			80	PULLMAN
N P RY	42	397	28				654	60	22 10 AXLE	60 HEAD END	56	60	23278				
A C L RY	20	360	292						20	30			448		288		
CANADIAN PACIFIC	277	498	3878						277	24			5664		874		
C & E I RY	64	80	51	2	30				62	30			1040				
D L & W RY	35	167	556	9					44	30			704				
G N RY		260	42		32	60			1 2	30 60	50	60	3044				
C B & Q W RY	80	41	82						80	30			800		750		
C & A RY	24	31	117						7 17	30 60			1168				
C M & ST P RY	6	626	4	926	17	60	620	60	11	60			2432				

Analysis of Car Lighting Equipment.

Name of Railroad	No. of Cars Electric Lighted only	A. C. Arc Lamps: Open Series	A. C. Arc Lamps: Multip. Enclosed	A. C. Arc Lamps: 6.6 Amp. Enclosed	D. C. Arc Lamps: 6.6 Amp. Magnetite	D. C. Arc Lamps: 4 Amp. Magnetite	D. C. Enc. Arc: 220 Volts	D. C. Enc. Arc: 110 Volts	Flaming Arc Lamps: Multip. A. C.	Flaming Arc Lamps: Series A. C.	Flaming Arc Lamps: Mult. D. C.	Tungsten: Watt 500	Tungsten: Watt 400	Tungsten: Watt 250	Tungsten: Watt 150	Cooper-Hewitt Lamps: Type F	Cooper-Hewitt Lamps: Type H	Motors H. P.: A. C.	Motors H. P.: D. C.	Remarks
B. & O. Ry. Co.	123	....	106	1196	40	60	70	255	17	22	1	....	30	255	....	....	....	8963	1007	We believe A. C. motors more economical to maintain than D. C. motors. We believe the large tungsten lamp can replace the regular arc lamp with increased efficiency in most places.
Ill. Central Ry.	236	40	....	....	....	....	40	....	....	2	....	50	300	400	....	....	....	4200	450	A. C. motors are preferred to D. C. for general shop operation. We think the large tungsten better for lighting railroad shops than the arc lamp.
St. L. & San Fran. Ry. Co.	237	....	....	....	....	....	....	75	....	....	....	25	....	75	....	....	....	1365	75	A. C. motors preferred for general shop operation. Variable speed tools can be taken care of by a small motor generator set.
Canadian Pacific Ry. Co.	277	....	....	....	....	....	....	65	....	110	....	....	....	....	....	....	....	12800	....	Prefer A. C. current on account of higher efficiency in transmission, and lower cost of maintaining motors.
San Pedro, Los. Angeles & Salt Lake Ry. Co.	....	....	....	....	....	....	....	18	....	....	....	120	....	....	....	....	....	1500	450	Large tungsten lamps can replace arc lamps, with greater efficiency and lower cost of operation.
Central of Georgia Ry. Co.	12	....	....	....	....	90	....	100	10	....	....	....	....	200	....	131	49	1800	1800	We believe the 220 volt tungsten lamp will replace the arc lamp. Both A. C. and D. C. motors are necessary in railway shop operation.
Chicago Gt. West. Ry. Co.	80	....	....	....	....	....	....	....	....	....	....	....	50	350	....	....	....	....	1831	Have replaced all our arc lamps with large tungsten lamps. A. C. or D. C. motors for shop use are governed by conditions, current obtainable, and operation.
Great Northern Ry. Co.	...	....	....	....	....	....	....	600	50	....	....	20	....	24	20	....	....	5020	....	We believe the large tungsten lamp much better for general shop lighting than the arc lamp. If proper attention to the layout of power plants and proper H. P. is installed in shops, A. C. current motors are more efficient and will stand more hard usage, with less repairs, than D. C. motors.
C., B. & Q. Ry. Co.	108	....	....	....	....	....	....	....	15	....	....	....	....	....	....	....	....	2916	3092	We believe the large tungsten lamp will replace arc lamps, and are replacing arc lamps with them.
N. P. Ry. Co.	42	....	....	....	....	....	....	350	20	....	....	....	100	....	....	....	....	....	....	We believe A. C. motors the best for 98 per cent of railroad shops work. There might be a condition where D. C. power would be necessary. Under such conditions, a small motor generator would supply the D. C. power.
C., M. & St. P. Ry. Co.	6	....	....	....	....	....	389	....	....	....	....	14	....	....	8	....	....	155	9721	We consider the large tungsten capable of replacing the 6.6 amp. arc lamp.
A., T. & S. F. Ry. Co.	55	....	....	....	....	....	....	963	....	....	50	120	100	76	....	....	....	1707	1560	We believe the large tungsten lamp can replace the arc lamp, and in new work are generally installing them.
Galveston, Harrisburg & San Antonio Ry. Co.	...	....	....	....	3	....	....	....	....	....	....	28	....	42	250	....	....	700	....	It is our opinion that the large tungsten lamp can replace the arc lamp.
L. V. R. R. Co.	251	287	....	191	....	....	....	....	8	....	....	6	....	....	....	....	....	3025	3970	It is our opinion that the large tungsten lamp can replace the arc lamp. Prefer A. C. motors where same will meet conditions of service.
Atl. Coast Line R. R. Co.	...	....	....	....	....	....	....	....	....	....	20	142	....	....	....	....	....	2202	1320	Tungsten lamps are considered preferable to arc lamps. D. C. motors are more efficient for general shop work than A. C. motors.
Pullman Co.	5322	....	....	2	....	....	....	....	136	....	50	20	....	1400	....	....	....	5500	1400	Large tungsten lamps can be used where arc lamps were used with economy. A. C. motors best for constant speed machinery, D. C. for variable speed.
Erie R. R. Co.	...	35	....	150	....	....	....	....	65	....	....	25	....	....	....	....	....	....	....	We prefer 4-lt. 100-watt lamp cluster to single tungsten; it will replace an arc lamp. We prefer 3-phase, 60-cycle, 220-volt motors to all other classes.
Wabash R. R.	...	....	....	12	....	....	....	....	75	....	....	....	....	55	....	....	....	....	....	Where large tungsten lamp does not have to be placed more than 30 ft. high, it will replace an arc lamp. We prefer A. C. to D. C. on account of its flexibility over large areas for general shop practice.
C. & A. R. R. Co.	24	....	....	73	....	....	....	....	10	....	....	....	....	245	....	....	....	2041	....	
Gt. Western Ry. of England	568	126	....	66	....	....	....	....	1126	....	....	10	....	25	....	....	....	....	7949	It is our opinion that large tungsten lamps can replace the 6.6 amp. arc lamp. We consider the D. C. motor much more satisfactory for machine tools of all kinds than A. C. motors.
Penn. R. R. Co.	...	Enclosed 2051	....	190	120	529	18.-2 Series 90	80.-2 Series 2948	98	107	389	500	....	2059	....	....	....	17791	22476	Under certain conditions of service, we find that it may be possible to substitute the 250-watt tungsten lamp for the 5 amp. multiple burning D. C. arc lamp.
El Paso & Southwestern Ry.	...	8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	356	We believe the large tungsten lamp can replace the 6.5 amp. arc lamp.

is very extensive and is undoubtedly increasing. The reason for this is undoubtedly, lower first cost, greater reliability and low maintenance cost of the A. C. motor and also because of the great reflexibility of the A. C. system, in that a large territory surrounding the shop or roundhouse can be readily served from the same central plant.

Car Lighting Equipment.

Table No. 2 is of no great value as only 22 roads, out of a total of 60 written to, supplied the necessary information. However, on these 22 roads there has been a large increase in the number of electric lighted cars and a large decrease in the number of oil-lighted cars reported a year ago. There also has been a considerable decrease in the number of gas-electric combination equipment.

All these figures point to a gradual increase in the use of electricity for lighting railroad trains and this fact must be of considerable satisfaction to you electrical engineers, who are striving at all times to improve the service of your respective departments.

Referring to the tables of comparative statements of axle belts, you will note that the cheapest belt costs less per 1,000 miles of operation than the more expensive belts.

This may or may not mean very much, for there are often conditions existing on a railroad which affect the life of equipment even more than the quality of that article. And furthermore, reliability is generally a more important consideration in railroad service than the operating cost.

Ball Bearings.

One bearing company advises that there are over 2,500 car lighting generators now equipped with ball bearings and one of the large railroad companies in the east reported an extensive test to determine the frequency at which bearings must be greased.

After filling the bearings about two-thirds full of grease, these machines were sealed so as to absolutely prevent their being lubricated without breaking the seals, and the cars were run with these seals unbroken for a period of six months.

During this six months' trial these cars averaged about 350 miles travel per day without any inspection of the grease during this period. At the conclusion of the test, when the seals were broken, the bearings were found well lubricated with no grease inside the machines, and the grease cavities were found to be about one-third full of grease. The bearings were found to be in as good condition as on the day of the beginning of the test, when they were originally sealed. At the completion of this six months' period, the brushes on these generators were found to have suffered but very little wear, and there was no sign of wear on the commutator. These three cars were in service during this six months' period with no light failure or interruption to the lighting system, and there were no machine or other repairs required. The only attention necessary was the usual belt adjustment, and the only inspection made was that commutators and brushes were examined at intervals of two weeks, but with no defects found on these inspections.

As a result of this test it has now been arranged that all types of ball bearing machines will be taken care of on a schedule of six months' periods of lubrication, as the results of this test prove that this schedule is not only economical, but is absolutely safe.

Respectfully submitted,

C. R. Silman, chairman.
B. F. Wood.
Geo. W. Cravens.
A. C. Moore.
C. H. Jones.
Edward Wray.

COMPARATIVE STATEMENT OF MILEAGE ON AXLE DYNAMO BELTS AS PER TESTS MADE DURING PAST THREE YEARS BY ROCK ISLAND LINES.

Kind of belt	Avg. No. belts used per month.	Average total mileage per Mo.	Avg. Miles per belt per month.	Avg. No. belts lost per month.	Avg. No. belts torn and worn per month.	Average per cent belts lost per Mo.	Average per cent belts torn and worn per Mo.	Average length of belt	Average cost per foot	Average cost per belt	Average cost per 1,000 miles.
A	40.7	868,524	21,332	29.3	11.4	71.9%	28.5%	10′ 6″	$0.58	$6.09	$0.285
B	70.2	870,097	12,385	51.1	19.1	72.8%	27.2%	10′ 6″	$0.42	$4.41	$0.34
C	62.6	912,747	14,587	49.9	12.7	79.7%	20.3%	10′ 6″	$0.34	$3.58	$0.245

STATEMENT OF PERFORMANCE OF C AND D AXLE BELTS FOR 14 MONTHS—JANUARY 1, 1912, TO FEBRUARY 28, 1913.

Month.	No. of belts applied.	Per Ct. belts torn or worn.	Per Ct. belts lost.	Avg. Mls. per belt	Avg. Mlg. per belt worn.	Avg. Mlg. per belt lost.	Cost per 1000 miles.
January	10	20 %	80 %	3,251	3,614	3,161	$1.10
February	28	7	93	4,742	7,097	4,561	.735
March	89	14.6	85.4	4,650	4,182	4,730	.77
April	33	36	64	7,996	10,135	6,773	.447
May	37	27	73	10,252	12,471	9,434	.349
June	24	29.1	70.9	13,152	16,632	11,718	.272
July	46	45.6	54.4	17,359	20,589	14,646	.206
August	44	20.5	79.5	12,825	19,209	11,183	.279
September	41	24.4	75.6	24,530	19,418	26,179	.146
October	38	28.9	71.1	17,425	17,940	17,216	.205
November	44	25	75	19,534	27,680	16,819	.183
December	85	24.7	75.3	19,722	28,872	16,719	.181
1913							
January	173	11	89	20,145	17,472	20,474	.177
February	184	16.3	83.7	11,896	16,029	11,091	.301
Total 14 months	876						
Average per month	62.6	20.3	79.7	14,587	17,747	13,778	.245

Average length of belt, 10 feet 6 inches.
Average cost per foot, $0.34.
Average cost per belt, $3.58.

Average miles per belt, 14,587.
Average cost per 1000 miles, $0.245.

The Gas Electric Car—Characteristics and Operating Features

L. C. Josephs, Jr., Engineering Dept., General Electric Company

There are many reasons why a paper on gas electric cars should be of interest to the Association of Railway Electrical Engineers. Probably no department of modern railroads has shown such marked growth in the last few years as the electrical department, due to the introduction of electricity in new localities and novel employments. Rightly, all these new applications of electricity have come under the jurisdiction of the electrical departments, and the men of the electrical departments have found it necessary to investigate and become conversant with a great many new types of electrical apparatus.

The gas electric car although a hybrid piece of apparatus, containing both mechanical and electrical parts, is, however, best classified under an electrical heading, as the same class of labor which is required to supervise and maintain electrical equipment is desirable for the maintenance of the gas engine. For many reasons which will be apparent later, it seems expedient that gas electric cars should come under the jurisdiction of the electrical departments of our railroads.

There have been already presented from time to time a number of papers on the gas electric car, touching on all its features from general description to detailed operating costs, but up to the present time very little has been said on the electrical characteristics of these cars. Therefore the present meeting appears to be a fitting time and place to present such a paper.

From the large number of papers that have been written on the subject, you are no doubt all familiar with the general features of a gas electric car, that is a self-propelled motor car containing an internal combustion engine connected to a generator which drives the necessary traction motors through some suitable form of control. The idea of such a self-propelled car seems very simple to the uninitiated, but the design and choice of the various parts of the equipment is a very interesting and somewhat difficult study.

In order to make perfectly clear to you the purpose of this paper, a word may be here introduced to indicate the subjects that will be dealt with and the order in which they will be taken up.

The requirements of the electrical equipment for a gas electric car will first be taken up and it will be shown just how each part of the equipment should be chosen in order for it to fulfill its work. A brief description will then be given of the electrical equipment used on the car built by the General Electric Company. Next the matter of the proper operation of a car will be discussed. The manner of estimating the performance of a car and the class of service for which a car is fitted will be dealt with at some length. Finally in closing the question of the proper maintenance and supervision of a gas electric car will be mentioned.

REQUIREMENTS OF ELECTRIC DRIVE.

The first consideration in the design of any self-propelled car is the decision as to the proper size of engine required, and to show the difficulty in making this decision correctly, it need only be pointed out that nearly every designer of a self-propelled car has failed to choose the correct size of engine on his first attempt. From experience, however, it has been found that an engine rating of from 1½ to 1¾ kw. per ton of car is about the proper amount for service in this country for cars which occasionally haul trailers. In Europe where service conditions are easier, and schedule speeds are lower, the engine equipment required is much smaller. In giving this engine rating it should be considered as the continuous rating of the engine without overheating or injury. The maximum rating of the engine for short periods may be as much as 50 per cent more.

The electrical equipment of a gas electric car may be divided for convenience into three parts, namely, generator, motors, and control. These will be considered briefly in the above order.

Generators.

The generator required for a gas electric car should be about the most flexible machine that can possibly be designed. While usually operated at approximately a constant speed, it must be capable of operating under a wide range of speeds from 50 per cent below rated speed to 25 per cent above. It must build up or down in voltage quickly, so that in changing from one control notch to another, or passing from series to parallel connection of the motors, there will be no danger of flashing over. The current range of the generator must be from 50 per cent below to 200 per cent above its normal rating, and the voltage range must be from 70 per cent below to 30 per cent above normal voltage rating. The compounding of the generator should preferably be practically flat, and may be accomplished through the effect of the interpole field. This gives the desired result of quick building up of voltage, and gives the necessary compounding without impairing the commutation to any great extent, and moreover obviates the complication of a series field. The interpole field is necessary to secure good commutation over wide ranges of current, voltage and speed.

The generator armature must be of the most liberal design and free from any possible hot spots. It must have a very high temperature capacity for a short time, although the continuous temperature capacity need not be great. In order to prevent the generator building up to an excessive voltage when full field is impressed on it, it must be designed with the iron worked well above the knee of the saturation curve, so that it will be completely saturated at the desired upper limit of voltage. This, of course, means that the iron loss will be comparatively great when the car is running at high speeds with full voltage on the generator.

The proper kilowatt rating of the generator should be about 80 per cent of the engine rating. This rating, however, has very little meaning, as when the generator is operating on high voltage with high core loss, the current is low, and the copper loss is low, and vice versa, when the generator is operating on high current with large copper loss the voltage is low, with correspondingly low core loss.

Motors.

The motors used on a gas electric car can be of the standard railway type, thus permitting the use of equipment that has proven its merits by many years of service, and simplifying methods of maintenance and inspection, but as these motors must be operated under conditions of service such as found on the branch lines of many railroads, they must be of the most rugged construction, and capable of operating for long periods without attention. For the above reasons the lubrication and commutation must be exceptionally good, and in order to secure satisfactory commutation over large ranges of voltage, speed and current, the motors must be equipped with interpoles.

The total resistance of the motors and the wiring in

the series connection is an important consideration in the design of motor car equipments, as this resistance is the only limit to the current flowing at standstill on the first notch of the controller in the series position. If too great a current should flow on this notch, it would result in the stalling of the engine or in the failure of the generator to build up due to excessive armature reaction. This effect cannot be obtained by the use of external resistance on the first notch only, as it is often the practice in operating a car to start the car on the second, third or fourth notch, when there must be just the same protection against a great rush of current. On the other hand the total resistance of the motors and wiring should not be so high as to reduce the starting current, and therefore starting tractive effort to too low a value.

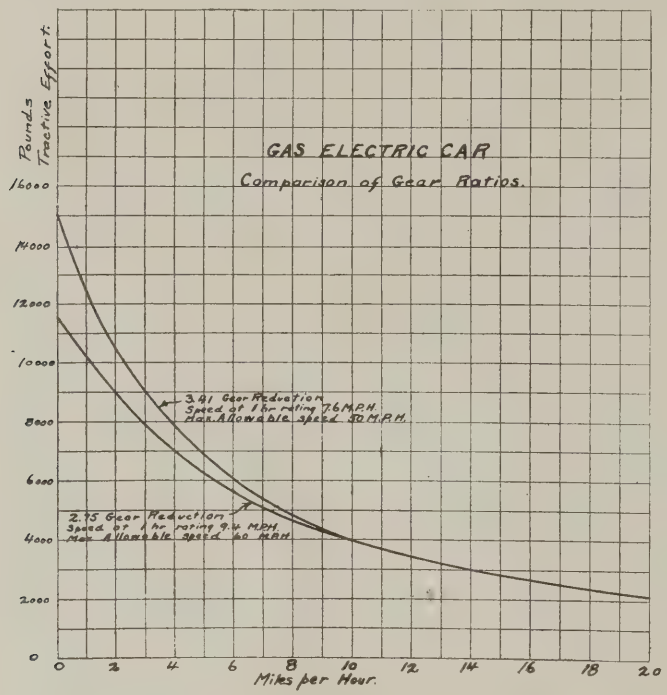


Fig. 1.

The permissible armature speed of the motor must be very high, as it is desirable to gear the motors so as to obtain a high tractive effort at starting and to have the speed at the rated load of the motors as low as possible, while at the same time the cars must be capable of traveling at very high speeds when coming down grade on good stretches of road. The choice of gear ratio and wheel diameter is an important consideration. In general for cars having 33-inch wheels and motors having an allowable maximum armature speed of 1,800 r. p. m. a gear reduction of about 2.75 is satisfactory. The choice of these various quantities depends of course on the motor used and the kind of service the car is going to operate in, remembering, however, that a car may be moved about from one service to another without consideration as to its gearing. The above combination is one that has been found satisfactory for single motor cars in average service where trailers are hauled occasionally. For 100-kw. generator output this combination gives about 12,000 lbs. tractive effort at starting, allows a maximum speed of 60 miles per hour, and allows a tractive effort of 4,200 lbs. at 9.5 miles per hour at the rated load of the motors. For gas electric locomotives and cars operating with trailers at low speeds, the maximum gear reduction obtainable is desirable. This gives slightly more tractive effort at starting, and a much lower speed at the rated load of the motors, but makes very little difference in the general speed-tractive effort relations for the equipment. To indicate how little this difference is, two curves are shown at Figure 1 giving the speed-tractive effort relations for similar equipments having different gear ratio of 2.75 and 3.41 respectively. It will be noted that above 10 M. P. H. the two curves are identical.

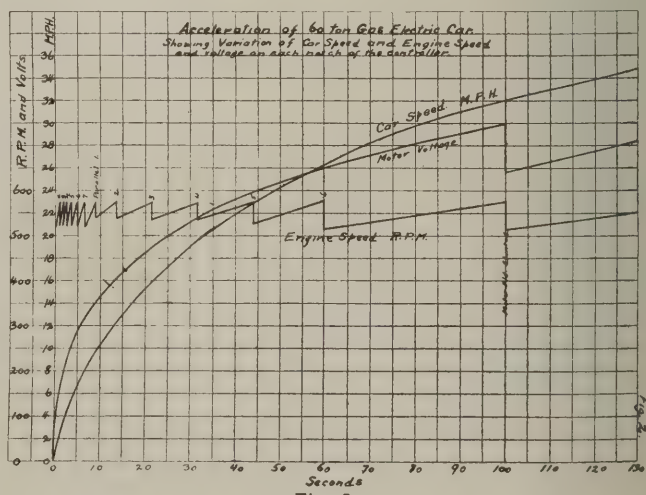
The motor rating on a gas electric car should be about 125 per cent of the generator rating. The reason for the apparent difference between the rating of the generator and motors on a gas electric car is easily accounted for by the different methods of rating the two types of machines. The generator according to custom is rated on a basis of a 50° C. temperature rise while railway motors are usually allowed 75° C. rise.

Control.

The control equipment for gas electric cars consists of three parts, namely, the engine control, the control of the motor connections, and the generator field control.

It is desirable in a gas electric car to have a variable speed engine on account of the added flexibility of the control as explained below. The engine control may be best obtained by means of a manually operated throttle in the intake pipe between the carburetor and engine inlet valves, which simply permits the varying of the amount of gas fed to the engine. The engine should be prevented from running away in case of sudden removal of load by means of some speed limit device of positive nature. The engine may be operated therefore at any speed from the point at which it will just turn over to the point at which the limit device will stop it. This is a desirable feature in adding to the flexibility of the control of the car, besides which it permits the operation of the engine for the greater part of the time at its most economical speed from the point of view of fuel consumption, but allows the engine to be speeded up on occasion to secure its maximum power output when operating on grades or when accelerating.

The arrangement of the motor connections may be controlled by means of the ordinary type of drum controller such as is used in trolley cars. The main cylinder makes the series or parallel connections of the motors with the generator armature. The auxiliary cylinder allows for the reversal of the direction of rotation of the motors.


Acceleration of 60 ton Gas Electric Car.
Showing Variation of Car Speed and Engine Speed
and Voltage on each notch of the controller.
R.P.M. and Volts
M.P.H.
Car Speed M.P.H.
Motor Voltage
Engine Speed R.P.M.
Seconds
Fig. 2.

The control of the generator shunt field current may be effected by any convenient form of field rheostat. This rheostat should best be operated by the same handle as the main motor controller. Thus for the series motor connection the generator voltage may be brought by successive steps from its lowest point to full voltage, the

motor voltage being at all times one-half the generator voltage and for the parallel motor connection the generator voltage may again be brought by successive steps from its lowest point to full voltage with the motor voltage now equal to the generator voltage. In practice it is

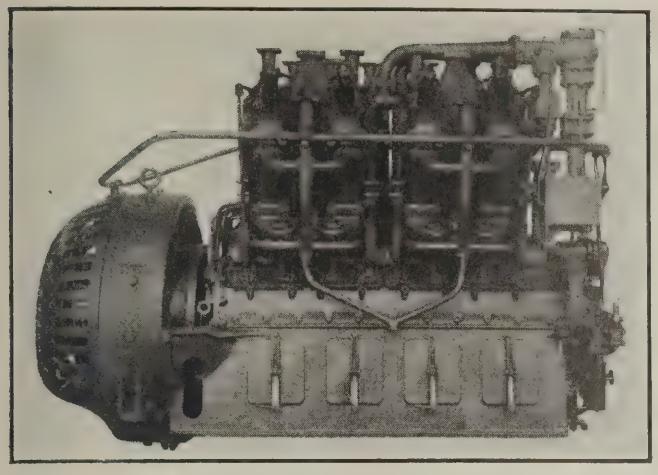


Fig. 3—Gas-Electric Generating Equipment.

found for ordinary motor car equipments that about 7 steps of voltage for the series connection of the motors, 6 steps of voltage for the parallel connection of the motors is the most desirable combination. This gives therefore 13 different points on which the motors may be operated. Moreover by varying the engine speed the voltage may be made to vary over wide ranges for each notch of the controller. This means a complete range of motor voltage from the lowest point of stability to the point where the generator field is fully saturated. As the current varies inversely with the voltage at any one engine speed, this means a corresponding range of current. In operating the car in order to obtain smooth acceleration, use is made of both control of the gener-

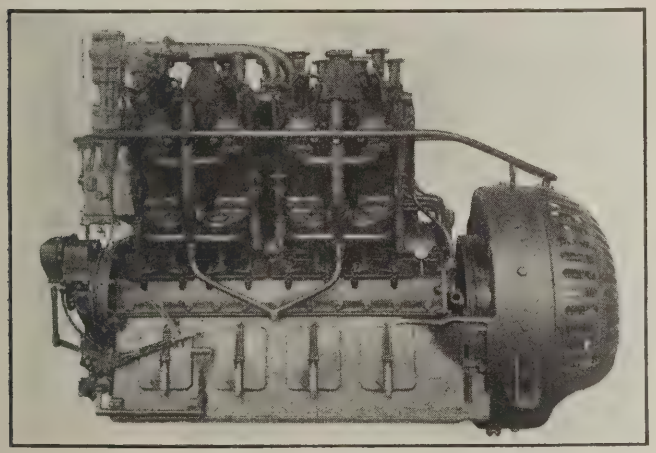


Fig. 4—Gas-Electric Generating Equipment Showing Engine Control Levers.

tor field and of the engine speed. This is best shown graphically by the curve at Figure 2 showing the variation of car speed, engine speed, and voltage during the acceleration of a 50-ton car.

The wiring and connections of the gas electric car are of the very simplest, similar to those found on any ordinary trolley car, and should need no description.

The suggestion of double end control for gas electric cars has been made on a number of occasions but has not met with great favor as yet. It has not been found particularly desirable to leave an engine of such size unattended for any length of time unless it is provided with a governor to maintain the speed correct. The feature of a variable speed engine is worth more in making a satisfactory car than any advantages due to double end control. The cost of installing wyes or turntables is usually an insignificant matter anyway.

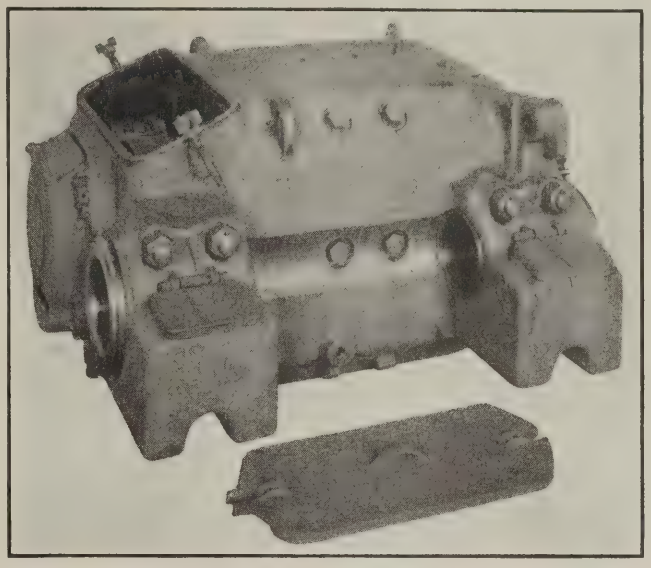


Fig. 5—Typical Electrical Railway Motor.

The idea of using a storage battery as an auxiliary on a gas electric car has been suggested occasionally. To disclose the weakness of this suggestion a few words would not be out of place here. In all the foregoing discussion of the requirements of an electric drive you have perhaps noted one point on which more stress has been laid than on anything else—that is the idea of vari-

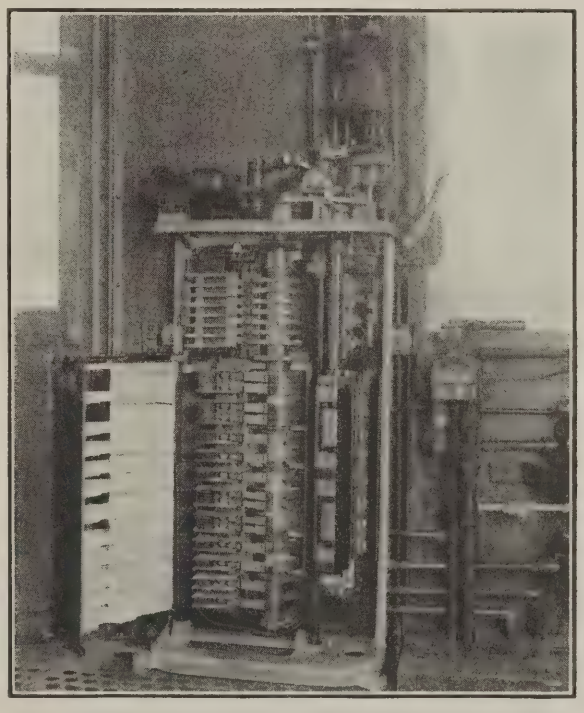


Fig. 6—Controller for Gas-Electric Equipment.

able voltage. A storage battery is primarily constant voltage apparatus and cannot be fitted into the plan of a gas electric car, without the use of relays and other parts to get out of order, unless the plan is so changed as to make the control entirely constant voltage. Moreover a battery large enough to be a real insurance against

total failure would be cumbersome and would add excessively to the cost of the car.

DESCRIPTION OF A GAS ELECTRIC CAR.

To show how the above requirements of electric drive may be easily fulfilled, a brief sketch follows of the electrical apparatus found on the cars made by the General Electric Company.

The engine on these cars is an 8-cylinder, 4-cycle,

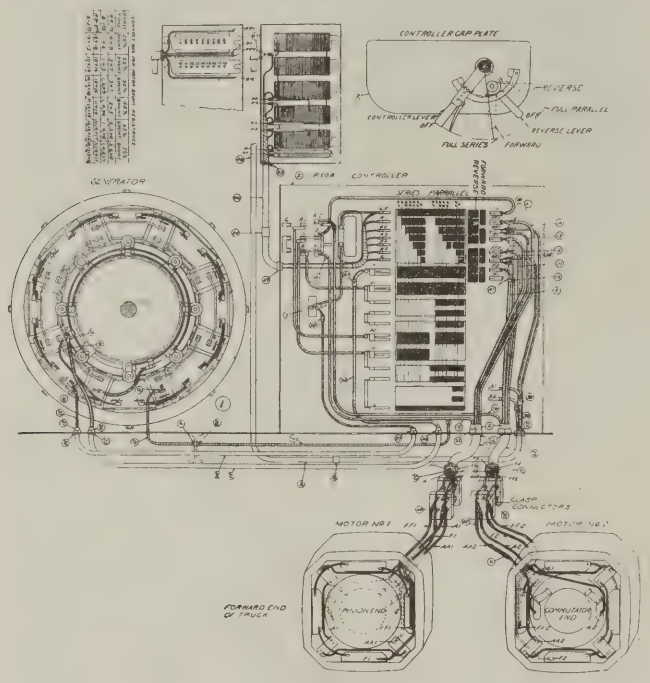


Fig. 7—Wiring Diagram for Controller with Motor Field Shunting Connections.

V-type of gasoline engine, rated at 175-hp. at 550 r. p. m. The generator provided is direct connected to this engine as shown at Figures 3 and 4. The generator is an 8-pole shunt wound commutating pole machine rated at 80 kw. 600 volts at 550 r. p. m. As the machine is direct connected to the engine, no inside bearing is provided, but an oil ring lubricated outboard bearing is carried on

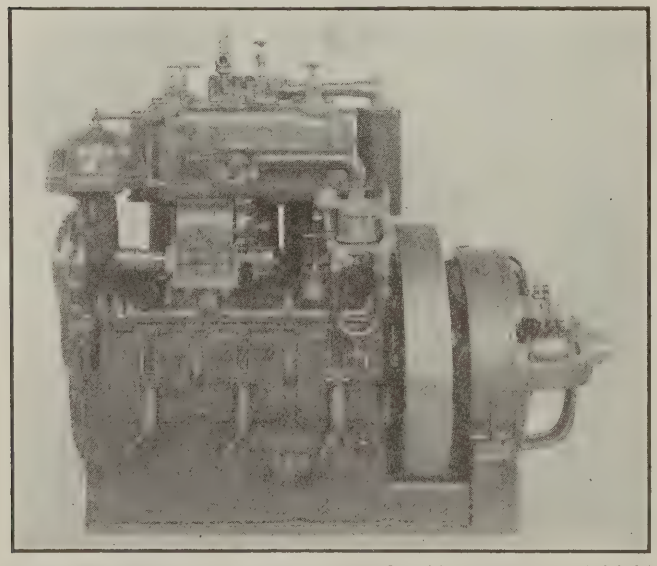


Fig. 8—Gas-Electric Generator Outfit for Air Pressure and Lights.

three arms bolted to the field frame. The motor equipment most often used on the General Electric cars is the G. E. 205 D- railway motor. This is shown at Figure 5. This motor is rated at 100 h. p. at 600 volts. The frame of the motor is of the box type, and is provided with interpoles. The gear ratio most commonly used with this motor is a 2.75 reduction with 33-inch wheels. The lubrication is effected by the usual oil and waste type of bearing and will operate for long periods without attention. These motors are of particularly rugged construction, and have been known to operate successfully for long periods without even lifting the covers for inspection, and they have therefore shown themselves well adapted to gas electric car work. In order to secure the full output of the power plant at car speeds above the point where full voltage has been reached, recourse has been had with very satisfactory results to shunting the motor fields. This has permitted the use of full power plant output almost up to the maximum speed at which the car can travel. It has been found possible to shunt the motor fields as much as 40 per cent in the case of motor cars which do not operate with trailers. The standard amount of shunting used, however, varies from 20 to 40 per cent according to the character of the service.

The controller used in these cars is of the common railway type shown at Figure 6. The large handle to the right of the center of the cap plate operates the main spindle to which is attached the cylinder for changing motor connections, below, and the cylinder for varying

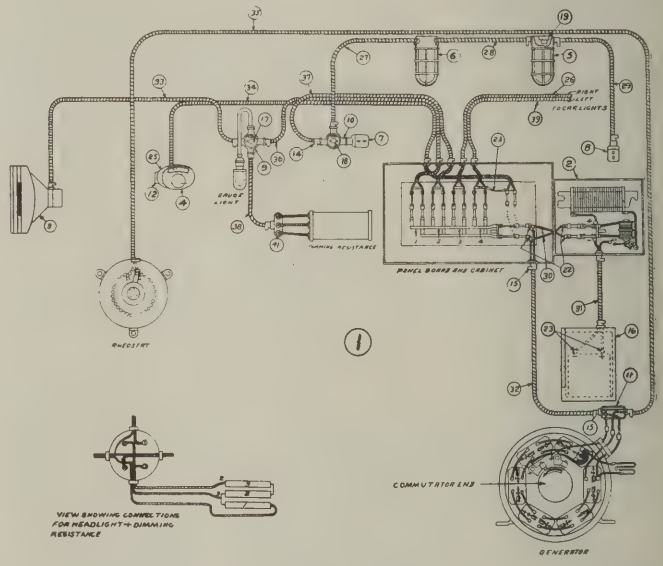


Fig. 9—Wiring Diagram with Headlight and Battery Charging.

the generator field resistance, above. The auxiliary cylinder is operated by the small reverse handle shown at the right on top of the cap plate. The secondary handle above the main controller handle is for the operation of the engine throttle. In starting the engine this handle latches with the air throttle, shown at left furnishing the necessary air for turning over the engine.

The generator field rheostat is mounted on the side of the car directly above the controller, and consists of wire resistances wound on porcelain bobbins. The power wiring for the car is shown on the diagram, Figure 7.

The lighting of these gas electric cars is furnished by means of a small 1½-kw. combined lighting set and air compressor driven by a two-cylinder gasoline engine shown at Figure 8. This lighting generator is a six-pole compound wound machine rated at 1½-kw. at 65 volts and 600 r. p. m. It furnishes the necessary current for lighting the car, driving small ventilating fans, and charging a small storage battery for the gas engine ignition. The wiring diagram of this outfit is shown at Figure 9. The charging of the storage battery is taken care of by means of a switch and battery relay. This relay is used merely to prevent the battery from dis-

charging in case the set should stop while the switch is closed, and is not intended as a cut out when the battery is fully charged. The relay is shown at Figure 10. The voltage of the lighting system is controlled by means of a small manually operated rheostat located beside the operator's position, but as the lighting generator is compound wound, the voltage regulation requires very little attention when once adjusted.

The only other electrical equipment of interest on these cars is the ignition system for the two engines. Both engines are equipped with Bosch magnetos furnishing low tension current to the Bosch magnetic spark plugs. The wiring for the main engine is shown at Figure 11 and for the auxiliary engine at Figure 12. The interesting point to note about the Bosch magneto is the construction of the armature with an auto-transformer winding, one part being a primary and the other a secondary. In setting the position of the armature of the magneto it is important to set the contact breaker in such a position that the break occurs at the moment when the rate of change of flux through the armature is the greatest, thereby securing the most intense spark.

OPERATION OF A GAS ELECTRIC CAR.

There are two conceptions of the gas electric car, and although both are logically correct, one will assist an

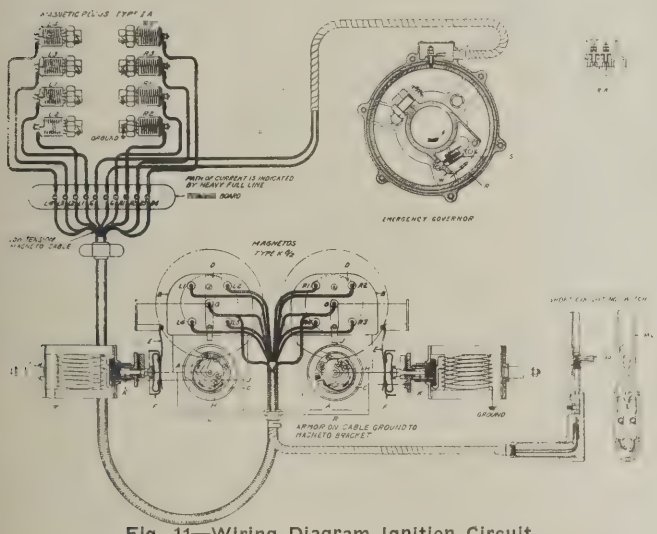


Fig. 11—Wiring Diagram Ignition Circuit.

operator in learning to handle a car while the other idea is likely to confuse him.

First we may consider a gas electric car as a large automobile equipped with an engine and driving wheels connected together by a transmission system having an infinite number of gear ratios. We may forget for the moment the existence of generator, controller and motors, and think only of the controller handle as a means for shifting the gears between engine and driving wheels. This is the first idea of the gas electric car, and the better one to adhere to.

Second, we may think of a gas electric car as a trolley car carrying its power house with it. From the appearance of the equipment and a good deal we have heard about it, this idea seems attractive, but is not a good way to look at the car from the point of successful operation.

The importance of the distinction of the above two ideas is very striking to anyone who has had experience breaking in as motor car operators, men who have had previous experience with automobiles, or men who have had previous experience on trolley cars. The former when starting a car will notch up slowly on the controller giving the car a smooth acceleration and keeping the engine at all times up to its proper speed. On reaching a grade they will drop back a few notches to keep the engine from slowing down with consequent loss of power. On the other hand the ex-trolley car man with the theory that the wider he opens the controller the faster he will go, rushes the handle round to the last notch, slowing the engine down almost to the stalling point, and only securing for acceleration about one-

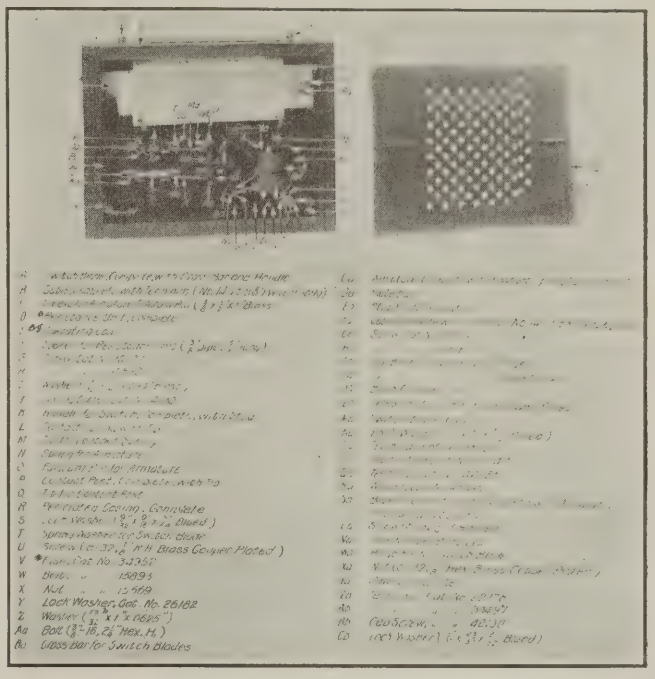


Fig. 10—Repair Parts for Car Panels.

fourth of the full output of the engine. If the engine would stall under these conditions, he would have to learn to operate properly, but unfortunately as the engine slows down, the generator voltage falls also, only much faster, as it is self-excited. This brings down the load until finally a point of equilibrium is reached at some very slow engine speed. The important factor to remember in operating a gas electric car is that the output of the power plant varies directly with the engine speed; the current in the power circuit varies with the counter E. M. F. of the motors plus the resistance of the circuits and varies with the generator voltage; and finally, the generator voltage depends on the generator speed and field excitation. All these variables must always be in a state of equilibrium, and if one variable is changed the others must change until a state of rest is reached.

For example, when the controller handle is moved

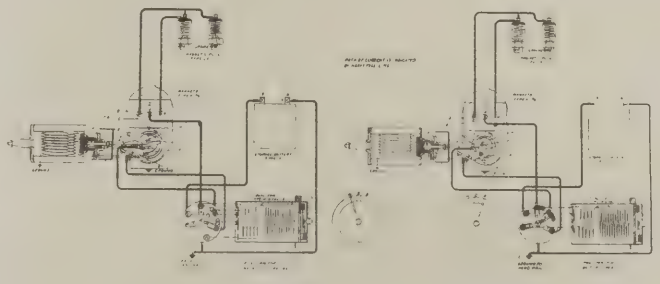


Fig. 12—Wiring Diagram Ignition Circuit.

ahead one notch the generator voltage is raised by increasing the excitation and as a result the current, power, and engine speed all decrease. Or if the car speed increased due to excessive tractive effort developed over that required by friction, the motor counter E. M. F. increases, the current decreases and the voltage, power and engine speed all increase.

The above two examples indicate what occurs regularly in the ordinary operation of the car in going from one notch to another, but in operating, care should be taken not to crowd the controller to such an extent as to allow wide variations of engine speed from the best operating speed, which is the speed of maximum fuel economy. From the above it will be seen that the car when going at a certain speed will operate with the controller on any one of several notches, just as an automobile will operate at any speed in any one of its gears, but for each car speed there is a certain control notch which is best to use. This is best illustrated by Table I, below, giving the car speed and tractive effort at various engine speeds on each notch of the controller. It will be noticed from this table that an engine speed of about 550 r. p. m. is the best to use, because this is the engine speed at which the tractive effort and speeds at each control notch are best distributed throughout the range of operation. At speeds lower than 550 several notches become worthless and at speeds higher than 550 r. p. m. the jump from series to parallel notches becomes too great.

PERFORMANCE.

In figuring on the service that a gas electric car can perform there are two important points to determine. First, the schedule speed that can be made, and second, whether the service can be maintained without overheating the equipment. As the amount of power that can be obtained for driving the car is fixed, it should be clear to anyone familiar with the usual Tables of "Kw. Input Per Car" found in railway hand books that the weight of car and frequency of stops in the service desired has a most important bearing on the question of schedule speed. The effect of grades also will be great if they are long and all happen to be in one direction. The methods used for the calculation of performance data for electric cars are well known and perfectly standardized. Up to the present time, however, nothing has been published on the methods of calculating service for gas electric cars, which, although a modification of electric car methods, are sufficiently novel to be worth an explanation. In electric car calculations it is customary to assume a definite motor current corresponding to some fixed rate of acceleration and to assume some value for average line voltage. By plotting speed time curves we can obtain root mean square currents and average voltages for the service and thus get the motor heating. In gas electric car calculations the only fixed quantity on which to base our figures is the fixed kw. generator output. The method of making these calculations is further explained at length. In order to illustrate the method best adapted to the calculation of the performance of a motor car for any given service, an example has been worked up for an imaginary railroad as tabulated in Table II.

TABLE II.
Service Conditions on A. B. & C. R. R.

Station	Miles	Max. Grade	Length, Ft.	Av. Grade
A	0			
		+ .1%	600	+.1%
		— .5%	1000	
B	2.2			
		+ .7%	1000	+.3%
C	3.1			
		+ .2%	2000	+.05%
D	5.6			
		— .4%	800	—.15%
E	10.4			
		+1.5%	10000	+.6%
F	14.2			
		— .7%	400	—.1%
G	18.7			
		— .3%	500	—.05%
H	20			

It is desired to operate this service with a 70-foot car and trailer, total weight of equipment loaded 85 tons. All station stops will be made and will be of 30 seconds duration each. The car will be equipped with a standard power plant and motor equipment consisting of engine and generator capable of furnishing 100 kw. continuously and two 100-h. p. railway motors. On account of space limitations, railway motors must usually be the most closely designed piece of apparatus in the equipment. They are, therefore, known to be the limiting feature so far as heating is concerned. Therefore any

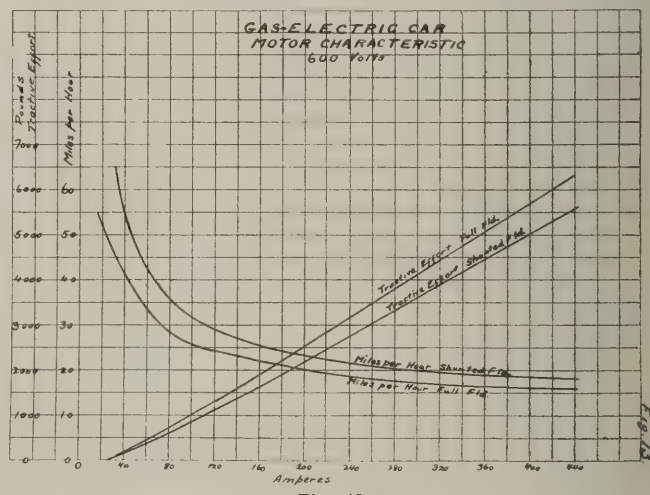


Fig. 13.

service which is not too difficult for the motor equipment to perform must be safe for all the other equipment on the car.

From the motor curve Figure 13 — it is possible to

Table of Tractive Effort and Speed.
TABLE I.

Engine Speed	650		600		550		500		400		300	
Notch	T. E.	Spd.	T. E.	Spd.	T. E.	Spd.	T. E.	Spd.	T. E.	Spd.	T. E.	Spd.
Series 1	....	0	....	0	....	0	....	0	....	....	....	....
2	6800	9.5	8350	6.4	11900	2.3	4570	0	....	....	....	....
3	6500	10.4	7650	7.6	9950	4.1	11100	0	....	....	....	....
4	6060	11.4	6850	8.8	8160	6.3	10950	2.8	....	....	....	....
5	5600	12.7	6250	10.5	7100	8.2	8340	5.7	4580	0	....	....
6	5180	14.3	5740	11.9	6350	9.9	7100	7.7	10000	2.8	....	....
7	4480	17.1	4850	15.0	5370	12.4	5860	10.3	7330	5.7	10450	1.5
Parallel 1	2820	29.3	3540	21.8	5300	12.7	10450	0	....	....	....	....
2	2700	30.8	3260	24.3	4300	16.7	9450	4.2	....	....	....	....
3	2520	33.5	2890	27.6	3500	20.7	4850	13.7	....	....	....	....
4	2320	36.0	2590	30.8	3000	25.7	3550	19.9	10450	0	....	....
5	2100	40.4	2380	34.6	2640	29.5	3000	24.4	4400	13.4	4580	0
6	1770	48.4	1960	42.0	2240	35.8	2430	30.8	3080	20.5	4550	10.2
Shunted 1	1730	49.3	1960	41.3	2220	35.0	2480	28.6	3740	15.1	3900	0
Flds. 2	1450	59.6	1610	51.3	1820	43.2	2000	38.5	2570	23.6	3860	11.6

calculate the characteristic curves for the gas electric equipment as follows. The output of the power plant of the car is taken to be constant at 100 kw. From a knowledge of the characteristics of the generator and control steps we can easily determine the voltage on each notch of the controller, and from this with constant output we can determine the current. These values are given at columns 2 and 3 on Table III. The volts and amps, per motor may be obtained directly from columns 2 and 3 by noting the motor connections. These values are shown at columns 4 and 5. The resistance drop per motor is next calculated from the current and ohmic resistance of motor and wiring. This is given at column 6. Now subtracting the values of column

TABLE III.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Gen.	Gen.	Motor	Motor	Resist.	Motor	Corr'd 600	M.P.H.	Corr'd Tract.
	Notch	Volts	Amps.	Volts	Amps.	Drop	Volts	Volts	M.P.H.	Effort
Series	1	232	430	116	430	116	0	16.0	.0	12500
	2	360	278	180	278	75	105	17.5	3.1	7500
	3	424	236	212	236	64	148	18.2	4.5	6200
	4	500	200	250	200	54	196	20.0	6.5	5000
	5	566	177	283	177	48	235	21.8	8.6	4460
	6	622	161	311	161	44	267	22.3	9.9	3800
	7	710	141	355	141	38	317	22.8	12.1	3250
Parallel	1	360	278	360	139	37	323	22.9	12.4	3200
	2	425	236	425	118	32	393	24.3	15.9	2560
	3	500	200	500	100	27	473	25.7	20.3	2000
	4	567	178	567	89	24	543	26.5	24.0	1600
	5	622	162	622	81	22	600	27.8	27.8	1500
	6	710	142	710	71	19	691	30.5	35.1	1300
Shunted Fld.	1	622	162	622	81	22	600	35.5	35.5	1280
	2	710	142	710	71	19	691	38.0	43.8	1000

6 from column 4 we obtain the motor counter E. M. F. on each notch. This is given at column 7. From the motor curve Figure 13 and by using the values of motor current at column 5, values can be obtained of car speed as given in column 8 and the values of total tractive effort as given in column 10. The speed in column 8, however, is on a basis of 600 volts and must be corrected to be in accordance with the motor voltage as given in column 7. This corrected result is given at column 9.

The results given in Table III are shown in the form of a curve at Figure 14, which gives the characteristic curves for a gas electric car.

From the values plotted in Figure 14 and from the well known values of train friction, it is possible by taking small increments of speed and time to calculate an

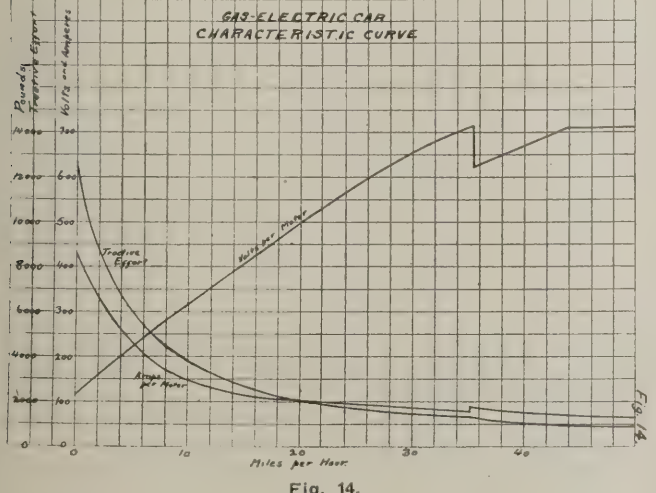


Fig. 14.

acceleration curve as shown at Figure 15, and similar to Figure 2. This acceleration curve should include also a curve of distance covered, a curve for the square of the current in one motor, and a curve for the voltage on one motor. One of these complete tests of curves should be plotted for each of several different grades, for instance level, .5 per cent and 1 per cent up grade. Now by working backwards to the curve of distance covered and by using a braking line corresponding to a deceleration of one mile per hour per second, we may terminate

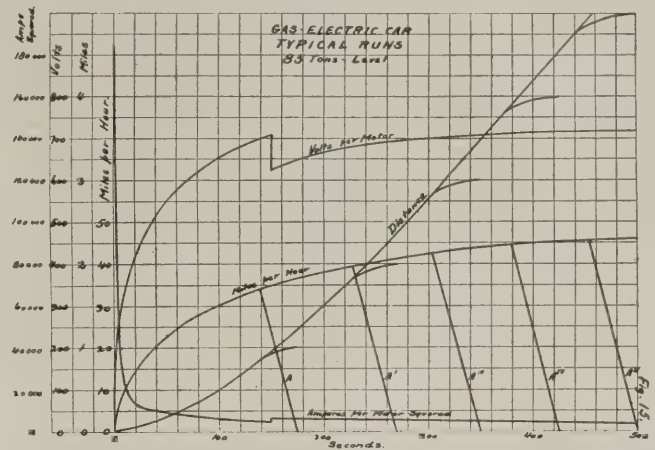


Fig. 15.

a number of runs so as to cover the 1 mile, 2 miles, 3 miles, etc., distance. These braking lines are shown laid in at A, A^1, etc., on the curve. For each of these runs the root of mean square motor current and the average motor voltage should be worked out. This can be very quickly done by the use of a small planimeter.

From the above values and from the values of time required for each run, we are now prepared to plot the curves given on Figure 16. These curves give the minimum time in seconds, the root of mean square motor current multiplied by time and the average voltage multiplied by time for three different grades plotted against length of run. From these curves and the data in Table II we can now make up Table IV. as follows:

TABLE IV.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stations	Miles	Seconds	Amps. squared multiplied by time	Volts multiplied by time	Seconds	Amps. squared multiplied by time	Volts multiplied by time
A.	....	....	.....	.....	....	.....	.....
B.	2.2	296	4,360,000	165,000	280	4,000,000	160,000
C.	.9	200	4,100,000	100,000	170	3,200,000	100,000
D.	2.5	320	4,400,000	182,000	310	4,200,000	180,000
E.	4.8	490	4,900,000	320,000	512	5,250,000	330,000
F.	3.8	(630	12,900,000	240,000)	410	4,700,000	260,000
		(270	4,000,000	155,000)			
G.	4.5	460	4,800,000	295,000	475	5,000,000	305,000
H.	1.3	210	3,550,000	120,000	215	3,650,000	360,000
8	20.	2876	43,010,000	1,577,000	2372	30,000,000	1,695,000
6 Stops at 30 sec.			180	Av. volts 550		180	Av. volts 715
			3056			2552	
			305			255	
			3361 |	43,010,000		2807 |	30,000,000
				12,800			10,650
Root Mean Square Amps.				113			103
Time Required				56 min.			47 min.
Schedule Speed				21.4			25.6

Columns 1 and 2 give the stations and miles between stations taken directly from Table II. Column 3 gives the minimum seconds required for each run in a direction from A. to H. using the miles between stations and the curves on Figure 16, making allowance for grades, etc. Column 4 is the root of mean square motor current multiplied by time and is found in the same way. Column 5 is the average motor voltage multiplied by time, also found from Figure 16. Columns 6, 7 and 8 are the same as columns 3, 4 and 5 only for a run in the opposite direction.

Now add up all the columns of this Table and divide the totals of columns 5 and 8 by the totals of columns 3

and 6 respectively, thus securing the average voltage for the entire runs. Add to columns 3 and 6 the time required for stops and increase these totals by a 10 per cent margin of safety. These final totals may then be divided into the totals of columns 4 & 7 respectively to secure the root of mean square motor current for the whole runs and from the final totals of columns 3 & 6 the schedule may also be figured and a regular time table made up for the run.

From the root of mean square motor currents and the average motor voltages the heating of the motors may be easily figured and the temperatures predicted, remembering that roughly for any one equipment the core loss varies almost directly with the voltage. If it is found that these temperatures will become excessive, the time required by the run must be lengthened out, or in some other way the service made easier.

The above method while approximate in some ways is reasonably accurate and permits of predicting motor temperatures very closely. Also, after a set of the above curves have been worked out for any one type of equipment, they are always applicable, and if the equipment is moved to some other run its performance can be very easily worked out.

In order to point out to you what may be expected of gas electric cars, there is given in Tables V, VI, & VII, the performance data which is regularly included in the specifications for General Electric motor cars.

TABLE V.

TABLE OF SCHEDULE SPEEDS IN MILES PER HOUR FOR GAS ELECTRIC MOTOR CARS IN FREQUENT STOP SERVICE.

Motor Car Weighing 45 Tons Loaded.

Miles Bet. Stops Per cent Grade	1	2	3	5	7	10	Free Running Speed
Level	19.3	26.5	31.1	36.3	39.5	41.8	55.0
0.25	18.8	25.5	29.5	33.9	36.4	38.5	50.6
0.50	18.3	24.5	27.9	31.5	33.5	35.1	47.2
0.75	17.8	23.1	26.2	29.1	30.7	32.0	40.8
1.00	17.1	21.9	24.3	26.8	27.9	29.1	34.3
1.25	16.5	20.5	22.3	24.4	25.5	26.4	29.4
1.50	15.7	19.0	20.7	22.1	23.0	23.8	25.5
1.75	14.9	17.6	18.9	20.2	20.8	21.3	22.7
2.00	14.0	16.3	17.3	18.3	18.8	19.1	20.5

These schedule speeds include 10% margin, this being equivalent to six minutes per hour. Stops of thirty seconds each are assumed.

TABLE VI.

TABLE OF SCHEDULE SPEEDS IN MILES PER HOUR FOR GAS ELECTRIC MOTOR CARS IN FREQUENT STOP SERVICE.

Motor Car Weighing 55 Tons Loaded.

Miles Bet. Stops Per cent Grade	1	2	3	5	7	10	Free Running Speed
Level	18.6	25.3	29.1	33.6	37.8	38.5	49.0
0.25	18.1	24.0	27.2	30.7	32.7	34.5	44.6
0.50	17.4	22.5	25.3	28.1	29.6	30.9	41.0
0.75	16.7	21.0	23.3	25.7	26.8	27.8	34.6
1.00	15.9	19.6	21.5	23.3	24.2	24.9	28.5
1.25	14.9	18.1	19.6	21.0	21.7	22.2	24.4
1.50	14.2	16.6	17.8	18.8	19.3	19.7	21.4
1.75	13.2	15.2	16.1	16.8	17.1	17.4	18.8
2.00	12.4	13.9	14.5	14.9	15.1	15.3	16.7

These schedule speeds include 10% margin, this being equivalent to six minutes per hours. Stops of thirty seconds each are assumed.

TABLE VII.

MOTOR CAR AND TRAILER WEIGHING 75 TONS LOADED.

Miles Bet. Stops Per Cent Grade	1	2	3	5	7	10	Free Running Speed
Level	17.5	23.0	26.5	30.0	31.9	33.4	41.6
0.25	16.6	21.3	23.7	26.4	27.6	28.7	37.2
0.50	15.9	19.6	21.4	23.4	24.4	25.0	33.0
0.75	14.6	17.8	19.3	20.7	21.5	22.0	26.3
1.00	13.8	16.2	17.4	18.5	18.9	19.3	21.6
1.25	12.7	14.7	15.5	16.3	16.6	16.9	18.4
1.50	11.7	13.1	13.7	14.3	14.6	14.8	15.8
1.75	10.5	11.7	12.1	12.5	12.7	12.8	13.7
2.00	9.5	10.2	10.7	10.8	10.9	11.0	12.0

These schedule speeds include 10% margin, this being equivalent to six minutes per hour. Stops of thirty seconds each are assumed.

With regard to heating of the equipment, it is interesting to note that the services which are most difficult for the gas electric car to accomplish are those operating at very low speed with high motor currents, and those operating at very high speed with high motor voltages. In the one case the copper loss is extremely high and will bring the motors up to the limit of temperature in a fairly short time. In the other case the core loss, friction and windage becomes so high as to cause the overheating of the equipment. Any services at average speeds are free from overheating of the motors unless the tonnage is excessive.

The question has been brought up from time to time as to an explanation of the reason why a gas electric car weighing say 50 tons and equipped with two motors of 100 hp. can make a better performance than a trolley car with similar equipment. Because the gas electric

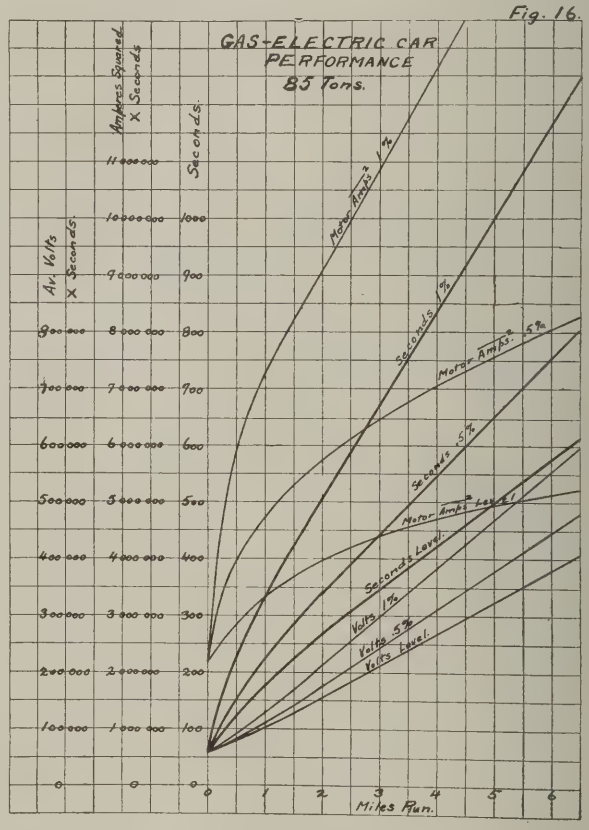


Fig. 16.

equipment is able to use excess voltage and field shunting it is able to go to higher speeds and can make higher schedule speeds than the trolley car provided the stops are far apart. To illustrate this there is given in Table VIII a comparison of a 40 ton

TABLE VIII.

COMPARISON OF GAS ELECTRIC AND TROLLEY CAR.

Miles per stop	10		2		½	
Car	Electric	Gas-Elect.	Elect.	Gas-Elect.	Elect.	Gas-Elect.
Schedule Speed	32.5	38	25	25	15	13.5
Copper loss per motor.	800	800	1300	1150	2250	1550
Core loss per motor...	1260	1900	1000	1150	600	550
Total losses per motor.	2060	2700	2300	2300	2850	2100

Weight both cars, 40 tons.
Average trolley voltage, electric car, 600 volts.
Constant power plant output, gas electric car, 90 K. W

gas electric car with a 40 ton trolley car, operating under three different conditions, both cars provided with similar equipment. From this you will see that for this particular equipment with a stop every 2 miles, the two cars are on even basis. With a stop every 10 miles, the

gas electric car is able to make a much better showing on account of high free running speeds while with two stops per mile the electric car has the advantage, on account of limited power in the gas electric. The rate of acceleration of the gas electric car is somewhat slow as compared with the electric car. This means, of course, a big saving for the gas electric car in the amount of power wasted, and this accounts for the reason the gas electric car is unable to make high schedule speeds in frequent stop service.

MAINTENANCE AND INSPECTION.

Before bringing this paper to a close, a word should be said as to the great importance of adequate maintenance of gas electric cars. In a great many ways the equipment used on motor cars is very similar to the train lighting equipment used on passenger cars, and requires very much the same kind of attention. On account of the characteristics of the gas electric motor car and because it is able to furnish light branch line service at low cost, it is customary often to find motor cars operating in out of the way points at the far ends of poorly paying branch lines. At such points of a railway system the shop facilities are usually poor, or none at all, the labor is unskilled, and the general standard of operation is probably the lowest on the system. This, of course, makes it hard for the satisfactory operation of the gas electric car, but it is a situation that is well known, and therefore steps are taken to meet it.

Any one who has had experience with a gas engine realizes the truth of the statement that the time to fix a gas engine is before it breaks down and not after. It has been the experience of those supervising motor cars that some large breakdown which perhaps required a day to fix was caused by the neglect of some small adjustment that could have been fixed in less than a minute by any one with a screw driver or small wrench. It is this kind of forehanded maintenance that is particularly necessary on gas electric motor cars, and it is for this reason that the instruction and examination of the operators is most important. So far as the class of labor required to operate motor cars is concerned, it has usually been customary to place on the car the steam engineer who formerly had the same run when it was steam service, and it has been found in general that a man of the caliber of a locomotive engineer is perfectly capable of making a good motor car operator, but it is absolutely necessary that he receive careful instruction, and this instruction should be of a broad nature, placing more emphasis on his understanding the equipment, than his being able to answer a larger list of questions. Where things can be explained by means of parallels found in the steam engine it is of advantage to do so, but care should be taken not to stretch the truth to too great an extent so that an engineer will for example compare shunting the motor fields to the hooking up of the reverse lever on a steam engine.

The motor car operators should be expected to make all adjustments to their cars and to look over the engine and other equipment at the close of every day's run and make out a work report if they find work that requires attention before the following day's run. It is then usually necessary to have one of the machinists from the round house or repair shop broken in to understand the motor car. This man's instruction should be more from the point of view of making repairs than from the point of view of operation. This maintainer will have to make all regular running repairs. The tools he will require will be no more than the ordinary hand tools of a skilled machinist. If the work of the operator in inspecting and adjusting his equipment is of the best character the work of the maintainer will amount to little more than putting in an occasional packing blown out, or some small labor of equally light nature. If the operator, however, is careless in his methods of inspection, the work of the maintainer will be correspondingly increased.

In order to check the work of the operator and maintainer it is important that a motor car should have an inspection at regular periods, and as a check, it is desirable that this inspection should be made by some other person than the operator or maintainer. The men best equipped to make such an inspection that we can find on a modern railroad are the electrical inspectors who look after the train lighting equipment. One of these men can be very quickly educated to understand the motor car, will usually take a keen interest in it, and can be sent at regular periods to visit the motor cars in his territory, and make the inspection of all parts both mechanical and electrical. The report made out by this inspector can be turned in to the main office as a record of the condition of each motor car from time to time.

The form of motor car reports has already been covered to some extent by Messrs. Dodd and Arnold in their paper before the International Railway Fuel Association on May 21st-1913, but too much stress cannot be laid on the importance of regular reports, and the easier these reports are to make out and send in, the more likely that the work will be properly done. The daily operator's report might best be made in postal card form to be sent forward by railway mail. The inspector's report would have to be much longer in order to cover all points, but if properly itemized and of convenient form, would be much more likely to be carefully filled out than if the inspector were merely provided with a sheet of blank paper.

The other persons interested in motor cars on railroads who should receive some instruction, are the round house foreman of the terminal where the car ties up, the traveling engineer of the district where the car is operating, and a number of extra engineers who can replace the regular operator when off duty.

Committee on Outside Construction and Yard Lighting

This Committee has devoted considerable time to the subject outlined and has reached the conclusion that the subject is so broad that it is impossible to attempt, at this time to submit a report that could, in any manner, be considered complete; and for this reason the attached report should be considered as a preliminary report only, based on such data and information as the Committee has been able to obtain up to this time; and it is hoped that the members will thoroughly discuss the various points under consideration in order that the Committee may have the benefit of such discussion in arriving at a more complete report, at some later date.

OUTSIDE CONSTRUCTION.

Poles.

General:

On account of local conditions and for the sake of appearance, concrete or steel poles should probably be used in some instances, although a sawed wooden pole would, in most cases, answer the requirements in this respect.

Where long spans are necessary, steel structures would probably offer the greatest advantage.

Wood:

Because of the low first cost and the fact that the tracks in railroad yards are frequently re-located, the use of wooden poles is recommended. The kind of wood used would depend almost entirely on the selection available in the location where the poles are required.

In order to increase the life of wooden poles, they might be treated by the open-tank or pressure process or simply be given a brush treatment at a point extended about 18 in. above and below the ground line, treating the gains and the top of the pole. Brush treatment is not very expensive, and would, in all probability, materially increase the life as the poles would be protected at points where decay is most apt to occur.

Another method of protecting the pole butts is to set them in concrete, extending the concrete below the surface of the ground a sufficient distance to give required protection, and above about 8 in. Mr. Keirn stated that he had in one case, removed a white pine pole that had been set in concrete; that this pole had been in service about 18 years, and that it was in good condition when he removed it. While the facts are not available, it was thought that the pole had never been treated or painted. The concrete in this instance extended some distance above the ground line. The Lackawanna Company have had some bored yellow pine poles set in concrete in use for six years, and these show no decaying action. These poles were not treated but painted after erection.

Concrete:

While the cost of concrete poles is high, it may be advisable to use them under special conditions where the track layout can be considered as a permanent installation. These poles will presumably have a very long life, but no actual figures seem to be available. There is a possible chance of failure of the poles due to electrolysis or a spawling of the concrete near the ground line due to absorption of moisture and subsequent freezing. A suggestion to minimize or eliminate this trouble, would be to treat the pole butts with crude oil to prevent absorption of moisture or encasing the pole at the ground line with concrete.

Steel Poles:

The life of these structures would vary depending on local conditions and the care taken to protect same by painting at proper intervals. The inspection and painting of these structures will be more or less expensive. In general, steel poles should be so designed as to facilitate, as far as practicable, inspection and painting. They should be set in or on concrete and when carrying high tension circuits should be grounded and inspected at sufficiently frequent intervals to assure a proper grounding at all times.

Spacing:

Under ordinary conditions, a spacing of approximately 125 ft. is recommended.

Clearance:

The minimum clearance for gauge line of rail to pole should not be less than 5 ft. 8 in., and all overhead lines should have a clearance from top rail of not less than 25 ft. 30 ft. if practicable.

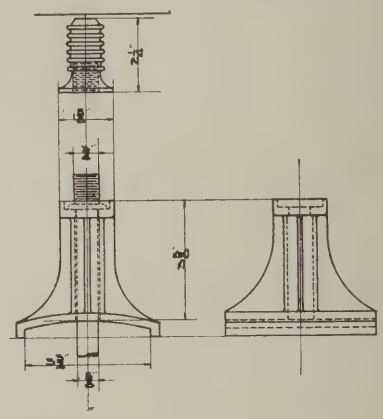
Cross-Arms, Insulators and Hardware:

All wooden cross-arms should have a cross section of not less than 3½ in. x 4½ in. One company, for power lines, uses 3¾ in. x 4¾ in. yellow pine arms with wooden pins 1½ in. x 8 in.

There seems to be considerable difference of opinion as to the advisability of the treating of cross-arms, but a brush treatment at the point where the arm fits into the gain is in all probability advisable. We do not favor the painting of cross-arms. Long leaf yellow pine is a very satisfactory wood for this purpose. Wood cross-arms should be properly fitted in the gains and held in place by not less than 1⅝ in. through-bolt fitted with a 2¼ in. x 2¼ in. x 3/16 in. square washer on each end. All arms should be fitted with iron or steel braces of not less than 1¼ in. x ¼ in. cross section. They should be attached to the cross-arms by not less than a ⅜-in. carriage bolt located at least 2 in. from pin hole and to the pole by not less than a ½ in. x 4 in. lag screw.

Wooden and Steel Pins:

Wooden pins should preferably be made of black or yellow locust. Where the pin strains are great, as when supporting heavy wires or at corner constructions, a steel truss pin as shown under Sketch No. 1 seems to be well designed for the purpose in that its base has a large



Sketch No. 1—Steel Truss Pin.

bearing surface on the arm, and a ⅝-in. bolt does not weaken the strength of the cross-arm materially. All hardware to be galvanized. No recommendations are being made as to the spacing of pins and cross-arms as the Committee still has this subject under consideration.

Insulators:

Porcelain (preferably brown) insulators designed for the proper working voltage and size of the conductor, are recommended, due consideration being given to any unusual conditions such as might occur when the insulators are subjected to an excessive amount of bitumi-

Sketch No. 2—Annealed Wire Tie.

nous coal smoke or moisture. When the wires are attached to the side of the insulator, the following method of attaching is recommended, as shown on Sketch No. 2: The tie to be annealed wire of the same size and insulation as the line wire up to and including No. 2 B. & S. gauge. When the line wire is attached to the top of the insulator, it is recommended that it be attached to the insulator by a clamping device, as shown in Sketch No. 3.

Safety:

It is recommended that all poles carrying 2,000 volts or over, be marked "Danger"; and that all series arc lamps be provided with absolute cut-outs of the type in which the lamp leads are detached from the cut-out and visible when the circuit is open. It is recommended that pole steps be used on poles supporting the lamps and

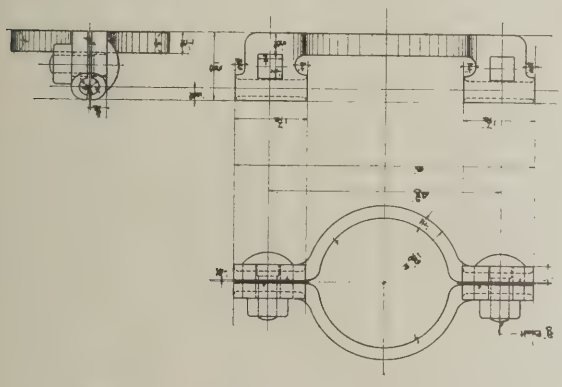
such others as may be required. The lower step should be placed approximately 18 in. from the ground line and the steps should be spaced 36 in. on each side, staggered so that the distance from one step to the next does not exceed 18 in. The steps should be so located that they are parallel to the track, and carried up the pole in this manner to a height of at least 15 ft., and then so placed as to give easy access to the cross-arms. An additional step should be added opposite the top step on each side of the pole.

Guying of Poles: The committtee has this subject under consideration.

DISTRIBUTION.

Overhead Systems:

It is desirable to eliminate as much as possible, overhead high tension distributing circuits, and for this reason it is recommended, where practicable, that electricity be supplied from one secondary distributing system. In a long narrow yard or very large yard of other shape, it



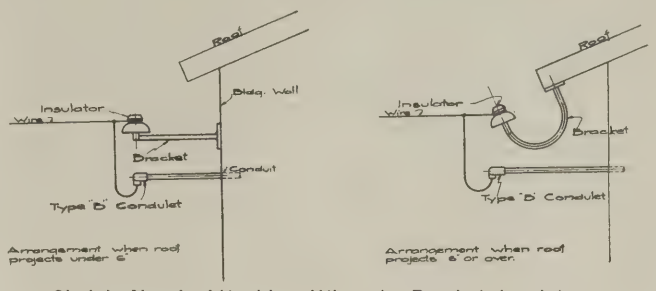
Sketch No. 3—Insulator Clamping Device.

may not be practicable to take care of requirements in this manner, but in this event two or more secondary distributing systems might be used, each receiving its power from one or more transformers. This general recommending will apply to both lighting and power, except when the power units or local lighting load were of such capacity as to make the same impracticable, in which case separate transformers could be used. It is recommended that with overhead construction, transformers be placed on poles, and that they be attached to an independent cross-arm or fixture located below the lowest cross-arm carrying wires. A high-tension disconnecting device located at transformer poles should be attached to the high voltage cross-arm so as to disconnect any high tension lines leading down the pole to the transformer. When required, a two-pole structure may be used to support large transformers.

Distributing circuits should be properly protected by lightning arresters, ground wires, or possibly a combination of both, with due consideration given the use of choke coils.

Secondary Lines:

When carried by the same poles, all secondary lines should be located below the high tension lines. Where a secondary circuit enters a building, a fuse and switch should be placed as close as possible to the entrance—the fuse so located as to protect the switch. The incoming wires should be attached to the insulators and supported by substantial metal brackets in such a manner as to avoid the possibility of moisture from the roof, grounding or short-circuiting the lines. See Sketch No. 4.



Sketch No. 4—Attaching Wires to Bracket Insulators.

Line wires:

We suggest No. 4 B. & S. gauge as a minimum size line wire, and that all line wires be stranded.

Underground Systems:

We believe it desirable to install complete underground conduit system in yards in preference to overhead construction for the following reasons:

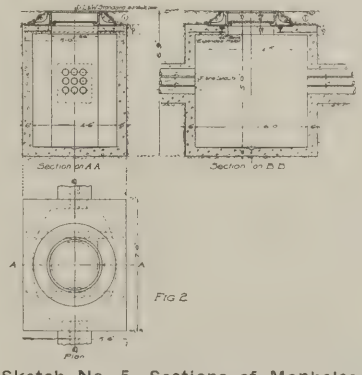
Greater assurance of continuity of service, elimination of accidents to pedestrians from broken wires, damage by storm or a general interruption of service on account of an individual pole having been broken down by derailment.

When this type of construction is once properly installed, the cost of up-keep should be very low. Further, any changes in the track layout does not interfere to the same extent as with overhead construction.

Conduit:

For trunk lines, would recommend the use of fibre conduit having 3½-in. bore and a wall of not less than ¼ in. thickness. Conduit to be protected by concrete, the thickness of which will be governed by local conditions. Under ordinary conditions, would suggest 1 in. of concrete between ducts with a 3-in. wall around the outside of ducts, the top of ducts to be at least 2 ft. below the surface of the ground.

For single duct branch lines, would recommend fibre of proper size having a bell or screwed joint; walls to be not less than ⅜ in. thick. Duct to be laid in the



Sketch No. 5—Sections of Manholes.

ground without concrete protection; top of duct to be protected by 1-in. boards at least 2 in. wider than the outside diameter of duct; top of duct to be at least 2 ft. below the surface of the ground.

Manholes:

In general, the distance between manholes should not exceed 400 ft. Trunk Line manholes should have an oval inside section with a minimum clear height of 5 ft., inside length of 6 ft. and 4 ft. 6 in. wide at the

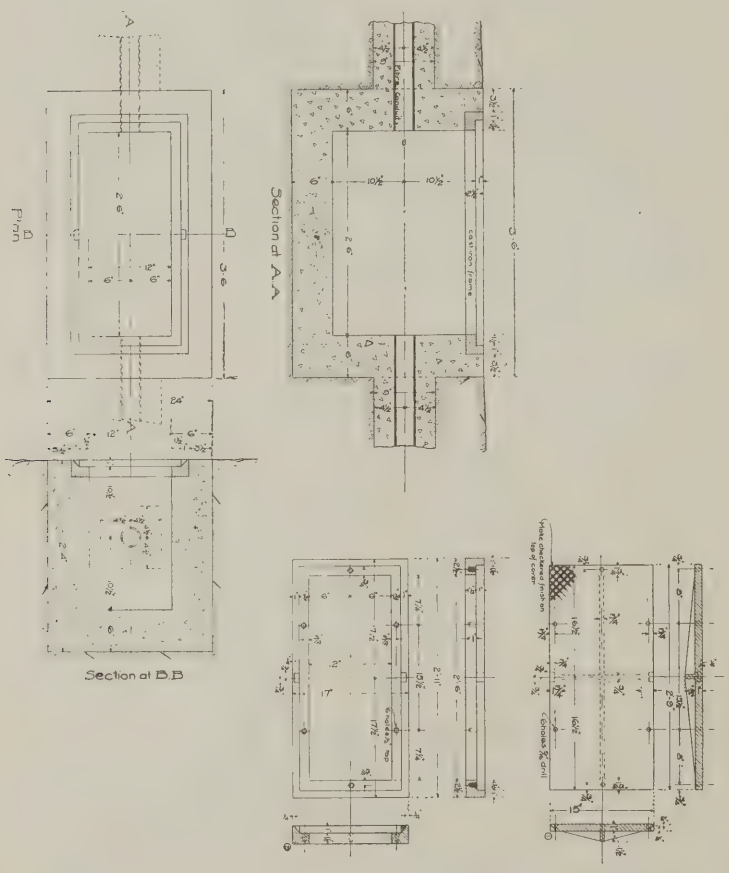
widest point. The casting at the top of manholes should be designed for two covers of not less than 24 in. diameter; the inside cover to be arranged for use with gasket if desired. See Sketch No. 5. It is very desirable, but not essential, in all cases, to drain manholes. (Expense of drain connections in some cases is prohibitive.) When used, would suggest locating drain pipes in one corner of the manhole floor, for if placed in center, they are apt to become blocked. Where the soil is of a sandy or gravel nature, a blind drain would be sufficient.

Branch Lines:

Should be provided with pull-in boxes to meet local conditions. See Sketch No. 6.

Cables:

For high voltage underground work, would suggest the use of lead sheathed cables in all cases and recommend varnish cambric as an insulating material. This



Sketch No. 6—Plan and Section of Manhole and Lamp Post Hole.

is preferable to rubber or paper because of its mechanical strength, heat resisting qualities, and it is not affected by oil.

For low voltage cables, would suggest the use of varnish cambric insulation or rubber, preferably varnish cambric.

The Use of Single Conductor Cables:

Recommend this for high tension series work; for low tension work where the size of each conductor exceeds No. 1/0 B. & S. gauge.

Distribution for Underground System:

High Voltage:

Place one or more banks of transformers at centers of distribution as may be necessary, locating transformers on poles or side of convenient buildings. High tension cables to transformers should terminate in porcelain distributing pot-heads. Would suggest the use of primary fuses on all transformers except when one of transformers is fed from a separate circuit which has its own protection.

Low Voltage:

The secondary of the transformers to be taken to a distributing panel located in a building as close to the transformers as is practicable. The secondary feeders to run from this point underground to the various buildings. Where taps are made at secondary underground mains, no fuse protection is to be used. (Cables to be fused where they enter building.)

Series Circuits:

For series circuits recommend using single conductor lead sheathed cable in duct as described, taking advantage of trunk line ducts where possible. For convenience of installation and inspection, a small concrete pull box should be placed near the base of each lamp pole. See Sketch No. 6.

We recommend either solid or bored wooden poles for supporting the lamps. The underground wires should be carried up the pole through the opening in the bored poles or in iron pipe attached to the side of solid poles; the bored type of pole is preferred for heights not exceeding 25 ft.

YARD LIGHTING.

We recommend liberal lighting at switches and general illumination for the entire yard. When new yards are being considered, due consideration should be given to the question of illumination and the track layout, such as to provide space for the necessary poles and to permit of proper track clearance. Railroad yards usually cover such a large area, that a series lighting system is best adapted to meet the requirements.

Type of Unit:

There are three types of series lamps offering the greatest advantages, which are: Carbon Flame, Metallic Flame, and Tungsten.

Carbon Flame:

Some of the advantages are—where conditions are very severe on account of smoke, the yellow carbon flame lamp seems to be best adapted because of the intensity and penetrating qualities of the yellow ray; and it can be used with A. C. or D. C. current.

Some of the disadvantages are—its high cost of maintenance; and that its light distribution could be improved if its candle power curve were more nearly approximated to that given by lamp of the metallic flame type; and the slagging of carbons.

Metallic Flame:

Some of the advantages are—long life of electrodes, flat distribution curve, freedom from the slag characteristics of the carbon flame lamp, lower cost of maintenance as compared with carbon flame. This lamp is also suitable for lighting large area on account of its high candle power and flat distribution curve.

One of its disadvantages is that it is restricted to direct current.

Tungsten Lamps:

Some of the advantages are—it is the most flexible of the types mentioned, and can be used on any series circuit and various candle power lamps on any circuit. When necessary to light large area, a number of units can be placed on one pole. The size or number of units used can be selected as desired.

Spacing and Height:

Carbon Flame:

For a lamp designed for not less than 7½ amperes, we recommend a spacing for general yard lighting not

to exceed 375 ft. For switch lighting, 250 ft. or less if required. The height of this type, not less than 32 ft. above rail, preferably more, say, 42 ft.

Metallic Flame:

For a metallic flame designed for not less than 6.6 amperes, we recommend the same spacing and height as recommended above.

Tungsten:

For a tungsten unit of 200 watt size, we recommend a spacing 125 ft. for general illumination and closer spacing for special location, such as switch points. Height 20 to 25 ft. above rail.

H. M. WARREN,
Chairman.
J. B. MCINTOSH,
W. H. KEIRN,
JOS. A. ANDREUCETTI,
C. J. CAUSLAND,
C. D. AXTELL.

Committee on Locomotive Headlights

Your Committee on Locomotive Headlights takes pleasure in submitting the following report:

At a meeting of the committee held in the spring, a blank form was drawn up and copy sent to 84 of the railroads operating in the United States as follows:

DATA ON LOCOMOTIVE HEADLIGHTS.

How many locomotives have you equipped with:

1.—Electric Headlights.
- Arc—
  - Freight
  - Passenger
  - Switching
- Incandescent—
  - Freight
  - Passenger
  - Switching
  - Dynamo
  - Straight Storage

2.—Gas Headlights.
- Acetylene—
  - Freight
  - Passenger
  - Switching
- Pintsch—
  - Freight
  - Passenger
  - Switching

3.—Oil Headlights.

4.—Other Types Not Mentioned

5.—Size of Reflector Used.

6.—How Many—
- Carbon—Carbon arcs
- Carbon—Copper arcs
- Luminous arcs

7.—Voltage of—
- Carbon—Carbon arcs
- Carbon—Copper arcs
- Luminous arcs

8.—What is the cost per equipment per mo
- Maintaining—
  - Carbon—Carbon arcs
  - Carbon—Copper arcs
  - Luminous arcs
- Operating—
  - Carbon—Carbon arcs
  - Carbon—Copper arcs
  - Luminous arcs

9.—Do you use electric classification lamps?

10.—Do you separate the cost of maintaining cab and classification lamps from the head lamp and machine?

11.—Do you operate in states having a compulsory law, and, if so, name the states?

12.—Do you wire your cabs in conduit, moulding or open work?
Which do you consider most satisfactory?

13.—What class of labor do you employ in maintaining electric headlights?

14.—Do you detail special men for this class of work?

15.—How many electric headlight equipments do you consider one man capable of handling in a ten hour day?

R.R. NO.	#1 ARC F	#1 ARC P	#1 ARC S	#1 INC. F	#1 INC. P	#1 INC. S	#1 DYNAMO	#1 BATTERY	#2 ACET F	#2 ACET P	#2 ACET S	#2 PINTSCH F	#2 PINTSCH P	#2 PINTSCH S	#3 OIL F	#3 OIL P	#3 OIL S	#4	#5	#6 CAR CARBON	#6 CAR CARBON	#6 CAR LUM	#7 CAR CAR	#7 CAB CAR	#7 LUM	#8 MAINTAINING CARBON CARBON	#8 MAINTAINING CARBON COPPER	#8 MAINTAINING LUMINOUS	#8 OPERATING CARBON CARBON	#8 OPERATING CARBON COPPER	#8 OPERATING LUMINOUS	#9	#10	#11	#12	#13	#14	#15
1	144	189					333		298		42				71		71		18	333			30								YES	NO	KANS. NEB. COL.	NO CON	ELEC	YES	
2	400	387					787										282		12 16	787			32		80¢						NO	NO	NO DAK. OKLA. TEX. MISS.	MOULD	DAYTON MACH	YES	25
3	1004						1004								528				18	1004			30		78¢				48¢		NO		YES	MOULD MOULD	ELEC MACH	NO	18 30
4	3 (TEST)						3								975				16 23	3			32		NO RECORD						YES	NO	NO	CON	DHDP ELEC	YES	
5																																	NO				
6	1512						1512								591							32	34		OPERATED ON CONTRACT						NO	YES	CON	HAMPTON 30 35			15 35
7	4	46					70								274		52		18 16	70			30		38¢				54¢		NO	NO	NO	OPEN	ELEC 34¢	YES	20
8	111	23					134										24		20 18	134			30		RECORDS NOT COMPLETE						YES		ARIZ TEX	CON	EXPER MACH EXP.	YES	15
9	457						457		128										18	457			32		NO DATA						YES	NO	TEX	CON	ELEC HELPER	YES	20
10															358	68	41		18												NO	NO	NO				
11	28	23					51										12		6	51			32		NO RECORD						NO	NO	N.C.	MOULD	MECH		
12		25					25												9 18	25			30		$6.00						NO	NO	NO	CON.	EXPERT ELEC	YES	15
13	457						457				128								18	457			32		NO DATA						YES	NO	TEXAS	CON	ELEC & HELPER	YES	20
14	305	58					363										26		18	363			30		NO RECORD						NO	NO	WASH. MONT. S. DAK.	OPEN CON	ELEC.	YES	9 12
15	548						548								1954					548			30								NO	NO	S.D. WIS. IOWA N.D.	COND & MOULD	MACH	YES	
16	200						200								300				18	200					NO RECORD						NO	NO	MINN. WIS N.D.	OPEN	ELEC. MACH.	YES	
17	33	30					63		4								5		18	63			32		NO SEPARATE CHARGE						YES	NO	WASH	CON	MACH & ELEC	YES	20
18	40	45					85												16 18	85			40		NO RECORD						FEW	NO	FLA.	OPEN	MACH	YES	
19										250					1064	73	213		18												NO	NO	NOT YET MISS.				
20															644	272	152		15																		
21															747	153	107		18																		
22		106					106								887					106			35		NO RECORD						NO		N.C.	CON.	ELEC HELPERS	YES	
23	7	9					16								34	20	11		18 18	16			32		NO RECORD						YES	NO	NOT YET MISS.	CON	ELEC.	YES	20 25
24	31	20					51												18	51			33								YES	NO	WASH MONT. WIS. S.D.	MOULD	ELEC & MECH.		
25									438	285	1				102	218	218		19 18																		
26															91				20														NO.				
27	167	68					255										56		17 18	255			34		$1.70		NO RECORD				NO		TEXAS	CON	MACH GENERAL	YES	30
28	55	14					69										5		18						NO RECORD						NO		KAN. OKLA. TEX	CON	MACH	YES	
29	1001						1001										157			1001		32									NO		NEW MEX. ARIZ. NEB.	CON.	MACH.	YES	
30		1					1			17					1690	326	173																				
31		21					21								441				5x 18	21			30		$2.96*						NO		NO	OPEN	ELECT. HELPERS	YES	20-25
32	700						700												18	700			30		NO RECORD						YES	NO	MON. WASH	OPEN	MACH.	NO	
33	171	80					251										18		16 23	251			30		$1.33				$0.70		NO	NO	GA	CON		YES	60
34	353	157					510								85	54	150		20x 23	446	64		30	110	$2.75 $4.15	$0.70*					YES		GA. FLA	CON	ELEC & MECH	YES	20
TOTAL OR AVERAGE	7781	1321					9073		868	562	171				10266	1134	1777		692	1256	6165	64	32.66	3463	110													

* MAINTAINING & OPERATING NOT SEPARATED

Table of Locomotive Headlight Equipments of Various Railroads.

The above reports indicate that no standard or uniform method of keeping cost of maintenance and operation of headlights have been practiced by any of the roads, and it is, therefore, impossible for your committee to offer any reliable data or information relative to same, and it is recommended that your committee on Standards be instructed to draw up a suitable form of report indicating means by which cost records may be kept.

In reference to the equipment, your committee recommends the following:

Turbo-Generator.

That wherever it is possible and practicable, the generating unit be installed on top of the boiler as near the cab as convenient and the exhaust pipe projected slightly above the cab and bent backward. The steam pipe to be tapped into the turret, when possible and provided with a suitable valve located inside the cab. A suitable strainer should be provided in the steam line and located as near the machine as possible and still be readily and easily accessible for cleaning.

Headlamp.

All headlight cases in which reflectors are used should have standard dimensions for each size of reflector, and the sizes of reflectors should be made as nearly uniform as possible, all 18-inch reflectors should have a standard depth and mounting height to permit of interchangeability. Reflectors of other diameters should have standard depth and mounting heights for each size.

For various reasons, your committee does not deem it advisable, at this time, to prescribe a definite standard.

Where high power headlamps are used, particular attention is called to the necessity of having the reflector properly set in the case and the case mounted on the locomotive so that the ray of light will be projected down the

center of the track and parallel with same. In no case should it be necessary to move the light out of its true focus in order to project it parallel with a straight track, for, by so doing, the light rays are more or less concentrated in a spot on the glass and may cause it to break.

In all cases, with high power lights used with parabolic reflectors, it is deemed advisable to use what is known as the "oval" or "heat resisting" glass in preference to the plain flat glass, either in one piece or in strips.

Wire.

It is recommended that whenever conductors of No. 8 B. & S. wire or larger are used that they be of stranded copper wire with slow burning insulation. All wires less than No. 8 may be solid conductor, but should have slow burning insulation. The use of rubber-covered wire, in connection with electric headlight installation, should be discouraged.

Classification Lamps.

When electric classification lamps are used, it is recommended that the lamp fixture be designed for combination oil and electric, and so arranged that in case of failure of the electric lamp it can be removed and the oil lamp used. A suitable switch or key socket should be used and installed in such a manner as to prevent the accumulation of soot in the socket. The use of switches in the cabs for controlling classification lights should be discouraged.

Cab Lights.

In all cases where electric cab lights are used, it is recommended that a fuse be placed in the cab circuit and located as close as practicable to the generator and easily accessible for the replacement or removal of same.

Running of Wires.

It is recommended that all wires leading from the generator to the head lamp house, or case, be run in rigid conduit, securely clamped to the handrail or other rigid part of the locomotive equipment, care being taken that it be installed as far as consistent from excessively heated parts.

The practice of running wires in handrails should be guarded against as much as possible on account of the frequent removal of handrails when taking off the jacket for the inspection of staybolts or for other reasons. All wires in conduits should be free from joints and all connections or splices thoroughly soldered and taped.

Laws Affecting Locomotive Headlamps.

Inasmuch as several of the states have deemed it advisable to enact compulsory headlight laws, which, when considered collective, render it impracticable, if not impossible, in some instances, for railroad companies engaged in interstate traffic to comply strictly with them, we quote for your information and consideration such laws as we have been able to obtain, as follows:

SUMMARY OF HEADLIGHT LAWS IN THE SEVERAL STATES.

Electric:

(1) Headlight of 1,500 candlepower, measured without reflector: Arizona.
(2) Headlight of 1,500 candlepower, measured with reflector: Missouri (effective January 1, 1914).
(3) Headlight consuming 300 watts at the arc: Georgia (23 in. reflector required). Mississippi (18 in. reflector required).
(4) Headlight sufficient to distinguish an object the size of a man at 800 feet, measured with reflector: Oregon (effective February 21, 1914).
(5) Headlight of design approved by Railway or Public Service Commission: Vermont, Washington.

Not Necessarily Electric:

(6) Headlight of 1,200 candlepower, measured without reflector: Colorado (effective April 3, 1914). North Dakota (effective July 1, 1914).
(7) Headlight of 1,500 candlepower, measured without reflector: Minnesota (effective January 1, 1914). Montana. Nevada (effective January 1, 1914). North Carolina. Oklahoma. South Dakota. Texas.
(8) Headlight of 1,500 candle power: Arkansas Florida (effective October 1, 1913). Indiana.
(9) Headlight of 10,000 candlepower, measured with reflector, or sufficient to distinguish an object the size of a man at a distance of 800 feet: South Carolina.
(10) Headlight sufficient to enable operator to distinguish an object the size of a man lying prone on track at a distance of 1,100 feet: Iowa (10 per cent by October 2, 1913; 10 per cent each 30 days thereafter).
(11) Headlight sufficient to distinguish a dark object the size of a man at a distance of 800 feet while train is running not less than 30 miles an hour: California (effective August 11, 1913).
(12) Headlight sufficient to distinguish an object the size of a man at a distance of 800 feet: Illinios (passenger train locomotives only; effective July 1, 1913). Kansas. Wisconsin.
(13) Headlight sufficient to distinguish an object the size of a man at 600 feet by a person of normal vision: Nebraska (effective January 1, 1914).
(14) Headlight sufficient to distinguish an object the size of a man at a distance of 450 feet: Illinois (freight train locomotives only; effective July 1, 1913).
(15) Headlight sufficient to distinguish whistling posts, land marks and other warning signs at a distance of 350 feet: Michigan (30 per cent by March 1, 1914; all locomotives by July 1, 1914). Ohio.
(16) Headlight sufficient to distinguish an object the size of a man at a distance of 250 feet: Illinois (switching, transfer or suburban passenger service only; effective July 1, 1913).
(17) Headlight of 50 candlepower, measured without reflector: Minnesota (switching locomotives only; effective January 1, 1914).

The penalties for violation of these laws vary from a minimum of $25.00 to a maximum of $1,000.00 each offence.

Attention is directed to the wide difference in the provisions of these Acts. These differences render it impossible in all cases for railways operating in more than one state to make use of appliances standard in one state in others through which they run. There is no Federal legislation on this subject, but bills are pending in the present Congress.

HEADLIGHT LAWS.

Arizona —Laws of 1912.

Section 1. It shall be the duty of every railroad corporation or receiver or lessee thereof operating any line of railroad in this State, within six months after the passage of this Act, or within such additional time as may be prescribed by order of the Corporation Commission of Arizona, after such railroad has made a proper showing of its inability to comply, to equip all locomotive engines used in the transportation of trains over said railroad with electric headlights of not less than 1,500 candle power, measured without the aid of a reflector: Provided, That this Act shall not apply to locomotive engines regularly used in the switching of cars or trains.

Section 2. Any railroad company or receiver or lessee thereof doing business in the State of Arizona, which shall violate the provisions of this Act shall be liable to the State of Arizona for a penalty of not less than $100 nor more than $1,000 for each offense and suit shall be brought to recover such penalty in a court of competent jurisdiction in the name of the State of Arizona, by the Attorney General or by the county attorney of any county in or through which said railroad may be operated.

Section 3. All Acts and parts of Acts in conflict with the provisions of this Act are hereby repealed.

Arkansas—Acts of 1907.

Section 1. Any company, corporation or officer of court, owning or operating a railroad over fifty miles in length, in whole or in part within this State, shall be required to equip, maintain and use, upon each and every locomotive being operated in road service in the State in the night-time, a headlight of power and brilliancy of 1,500 candle power.

Section 2. Any company, corporation or officer of court owning or operating a railroad over fifty miles in length, in whole or in part within this State, violating the provisions of this Act, shall be liable on conviction to a penalty of a fine of not less than $300 nor more than $500 for each separate offense, which shall be recovered in a civil action in the name of the State.

California—Laws of 1913.

Section 1. It shall be the duty of every railroad corporation, or receiver or lessee thereof, operating any line of railroad in this state, within six months after the passing of this Act, or within such additional time as may be prescribed by order of the Railroad Commission of California, after such railroad has made a proper showing of its inability to comply therewith, to equip all locomotive engines, used in the transportation of trains over said railroad, with electric or other headlights which will project sufficient light to enable the locomotive engineer to observe clearly a dark object the size of an average man at a distance of not less than 800 feet on a dark, clear night, while his train is running at a rate of speed not less than 30 miles per hour: Pro-

vided, That this Act shall not apply to locomotive engines regularly used in the switching of cars or trains: Provided, further, That this Act shall not apply to locomotive engines used exclusively between sun up and sun down, nor going to or from repair shops when ordered in for repairs, nor to locomotive engines used on short lines or local lines where, in the judgment of the Railroad Commission, the headlight herein provided for is not necessary for the preservation of public safety.

Section 2. Any railroad company, or receiver or lessee thereof, doing business in the State of California, who shall violate the provisions of this Act, shall be liable to the State of California for a penalty of not less than $100, nor more than $1,000, for each offense, and suit shall be brought to recover such penalty in a court of competent jurisdiction, in the name of the People of the State of California, by the attorney general or by the district attorney of any county in or through which said railroad may ze operated.

Section 3. All acts and parts of acts in conflict with the provisions of this Act are hereby repealed.

Colorado—Laws of 1913.

Section 1. It shall be the duty of every railroad corporation, receiver or lessee thereof, operating any line of railroad in this State, within twelve months after the passage of this Act, to equip all locomotive engines used in the transportation of trains over said railroad with headlights of not less than 1,200 candle power, measured without the aid of a reflector: Provided, This Act shall not apply to locomotive engines which are regularly employed in yard service, and known as switch engines: And provided further, That this Act shall not apply to engines running for a distance of not more than sixteen miles within the limits of this State, to complete their runs, nor to those used exclusively between sun-up and sun-down, nor to engines going to or returning from repair shops when ordered to such shops for repair.

Section 2. Any railroad company or the receiver or lessee thereof, doing business in the State of Colorado, which shall violate the provisions of this Act, shall be liable to the State of Colorado for a penalty of not less than $100, nor more than $1,000 for each and every locomotive not so equipped, counting each train hauled by such locomotive a separate and distinct offense, and such penalties shall be recovered and suit brought in the name of the State of Colorado in a court of proper jurisdiction, in any county in or through which such line of railroad may be operated.

Florida—Laws of 1913.

Section 1. That on and after October 1, 1913, all railroad locomotives operated in this state in the service of drawing passenger or freight trains shall be equipped with a first class headlight of not less than 1,500 candle power, which headlight shall be kept in good condition and used by those operating such railroad locomotive. That any person, firm or corporation who shall fail to so equip their or its locomotives used in drawing passenger or freight trains, as herein required, or shall operate and use a locomotive in drawing passenger or freight trains not equipped with a headlight as required by this Act, shall be guilty of a misdemeanor and shall, upon trial and conviction, be fined not more than $1,000, or imprisoned not exceeding twelve months.

Section 2. That all laws or parts of laws in conflict herewith be and the same are hereby repealed.

Georgia—1908.

Section 1. All railroad companies are hereby required to equip and maintain each and every locomotive used by such company to run on its main line after dark with a good and sufficient headlight which shall consume not less than 300 watts at the arc, and with a reflector not less than twenty-three inches in diameter, and to keep the same in good condition. The word main line as used herein means all portions of the railway line not used solely as yards, spurs and side tracks.

Section 2. Any railroad company violating this Act in any respect shall be liable to indictment as for a misdemeanor in any county in which the locomotive not so equipped and maintained may run, and on conviction shall be punished by fine as prescribed in Section 1039, of the Code of 1895.

Section 4. Provided, This Act shall not apply to tramroads, mill roads, and roads engaged principally in lumber or logging transportation in connection with mills.

Illinois—Laws of 1913.

Section 1. That all common carriers by railroads operating or doing business in this state shall be required to equip and maintain and use on all locomotive engines used by them in passenger service (except suburban passenger service) a headlight of sufficient candle power, measured with the aid of a reflector, to throw a light in clear weather that will enable the operator of same to plainly discern an object the size of a man upon the track at a distance of 800 feet from the headlight, and upon all locomotive engines used by them in freight service, exclusive of engines in switching and transfer service, with a headlight of sufficient candle power, measured with the aid of a reflector, to throw a light in clear weather that will enable the operator of same to plainly discern an object the size of a man upon the track at a distance of 450 feet from the headlight, and upon all engines used by them in switching, transfer and suburban passenger service with a headlight of sufficient candle power, measured with the aid of a reflector, to throw a light, in clear weather, that will enable the operator to plainly discern an object the size of a man upon the track at a distance of 250 feet from the headlight: Provided, This Act shall not apply to any locomotive engines running between sun up and sun down, nor to any locomotive engine the equipment of which has failed during the trip, providing it is shown that the equipment was in efficient and effective working condition when the trip was begun.

Section 2. That any common carrier by railroad violating any of the provisions of this Act shall be guilty of a misdemeanor and shall be subject to a fine of not less than $100 nor more than $500 for each offense.

Indiana—1909.

Section 1. That, in addition to the powers heretofore granted to the Railroad Commission of Indiana that said Commission be and it is hereby specifically empowered, authorized and directed, as soon as practicable after the passage of this Act, to investigate the conditions and efficiency of headlights now in use on locomotive engines on the railroads in this State, and if found to be inadequate for the protection of persons and property, or any other purpose, to investigate nad determine what would be the most practicable and efficient headlight for all purposes, and when the commission shall have so determined, to make and enforce against the railroad companies such order or orders as may be found to be necessary to require the equipment and installation of such headlights on the locomotives on the railroads in this State, and to this end said commission is given power in such investigation to examine the various kinds of lights that may be suitable for locomotive headlights and appliances therefor, to consult experts in such matters and to require the attendance of witnesses and the production of papers, documents, and appliances.

Approved March 6, 1909.

It is Therefore Ordered, That in the place of said headlights every railroad corporation or receiver or lessee thereof operating any line of railroad in this State shall equip all locomotive engines used in the transportation of same over the said railroads with headlights of not less than 1,500 candle power: Provided, This order shall not apply to locomotives regularly used in the switching of cars or trains.

It is Further Ordered, That all of said Railroad Companies shall equip one-third of their said road engines with said headlights by the first day of July, 1910, an additional one-third of their said engines by the first day of January, 1911, and the remaining one-third by the first day of July, 1911.

Iowa—Laws of 1913.

Section 1. It shall be the duty of every person, firm or corporation owning or operating any line of railway within this State of Iowa to equip all locomotives, power vehicles, power cars, or other equipment used as the equivalent of or in place of a locomotive, when used in the transportation of passengers or freight with a headlight of sufficient candle power, measured with a reflector, to throw a light in clear weather that will enable the operator of same to plainly discern an object the size of a man lying prone on the track at a distance of 1,100 feet from the headlight, and thereafter to maintain and use such headlights upon every such locomotive, vehicle, car or other equipment.

It shall be the duty of all such common carriers to so provide and equip ten per cent of the whole number of locomotives used by such carriers with such headlight within ninety days after the taking effect of this Act, and an additional ten per cent of such locomotives to be so equipped each and every thirty days thereafter until all such engines and locomotives, and other equipment used as equivalent thereof shall be equipped with such headlight.

This Act shall not be construed to apply to power cars used by street railways and operated wholly within the corporate limits of any city or town, nor to engines or other equipment used exclusively for switching purposes, nor to engines or other equipment running after runrise and before sunset.

Section 2. Any person, firm or corporation owning such lines of railway or the equipment operated thereon, who shall cause or permit any locomotive, power vehicle, power car, or other equipment used as the equivalent thereof, to be operated without being equipped with the headlight required by the provisions of Section One hereof, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than $100, nor more than $500 for each offense: Provided, however, That no punishment shall be imposed for the operation of any such locomotive or the equivalent thereof without such headlight, when such locomotive was properly equipped with such headlight at the commencement of the trip, providing it is shown that such headlight was in good and sufficient working conditions when the trip was begun and became disabled during the trip.

Kansas—1911.

Section 1. On and after January 1, 1912, it shall be the duty of every company, corporation, lessee, manager or receiver owning or operating a railroad in the State of Kansas, to equip and maintain and use upon each and every locomotive engine being operated in road service within the State of Kansas a headlight of a power that will outline the figure of a man on or adjacent to the track, plainly visible at a distance of 800 feet, preceding the locomotive. The visibility herein mentioned is understood to be measured by and under ordinary night conditions, and for the normal sight of a person having the usual visual capacity required of a locomotive engineer at his place in charge of a moving locomotive: Provided, That this Act shall not apply to engines running not more than ten miles into the State to complete their runs: And Provided Further, That this Act shall not apply to engines used in switching service: And Provided Further, That this Act shall not apply to locomotive engines used exclusively between sunup and sundown, nor on engines going to or returning from repair shops when ordered to such shops for repair.

Section 2. Any railroad company or the receiver, lessee, manager or superintendent thereof, violating the provisions of Section 1 of this Act, or who permits this Act to be violated when within his official authority to prevent its violation, shall be guilty of a misdemeanor and upon conviction shall be fined not less than $100 nor more than $500 for each offense, and the operation of one engine for any part of one day in violation of this Act shall be construed to be a complete misdemeanor.

Michigan—1913.

Section 1. Every railroad corporation operating a railroad or a part of one in this State, shall on or before the first day of July, 1914, equip each of its locomotives, except locomotives used exclusively in yard service, with a headlight of such construction and with sufficient candle power to render plainly visible at a distance of not less than 350 feet in advance of such engine, whistling posts, land marks, and other warning signs, and it shall be unlawful after such date for any such railroad to use a locomotive, except locomotives used exclusively in yard service, upon any part of its road lying within this State, that is not equipped with a headlight of such construction and candle power as will enable the engineer to see whistling posts, land marks, and other warning signs at a distance of not less than 350 feet in advance of the engine: Provided, That not less than thirty per cent of all the locomotives hereinbefore required to be provided with such headlights shall be so equipped on or before March 1, 1914.

Section 2. The State Railroad Commission shall from time to time inspect or cause to be inspected the headlights of all locomotives found in use on any railroads in this State. On discovering any defective headlight, the commission shall report the fact to the superintendent or other officer having charge of the road on which it is found, and the railroad corporation receiving such notice, shall thereupon cause such defective headlight to be immediately repaired, and if so ordered by the railroad commis-

sion, shall put the locomotive containing such defective headlight out of service until repaired and put in good working order: Provided, That should a headlight on any locomotive become defective when being used in transportation, it shall not be considered a violation of the provisions of this Act to continue the operation of such locomotive to its destination.

Section 3. Any railroad corporation using or permitting to be used on its line in this State, a locomotive in violation of any provision of this Act, shall be liable to a penalty of $100 for each violation, to be recovered in a suit or suits to be brought by the prosecuting attorney in the circuit court of the county having such jurisdiction in the locality where such violation occurred. Upon duly verified information being given him of such violation, such prosecuting attorney shall bring such suits. The railroad commission shall give the proper prosecuting attorney such information of any such violations as may come to its knowledge.

Minnesota—1913.

Section 1. Every person, company, corporation or receiver thereof operating any railroad in the State of Minnesota, is hereby required to equip, maintain and use upon every locomotive operated in road service in this State an electric or other headlight of at least 1,500 candle power, measured without the aid of a reflector: Provided, however, That this candle power shall not apply to locomotive engines regularly used in switching cars or trains: And Provided Further, That every person, company, corporation or receiver thereof, subject to the provisions of this Act, is hereby required to equip, maintain and use upon every locomotive engine regularly used in switching cars or trains, a headlight of at least 50 candle power, measured without the aid of a reflector: And Provided Further, That this Act shall not apply to locomotive engines used on branch lines less than twenty-five miles long and logging roads not over sixty miles long exclusively between sunup and sundown, nor when being taken to or returned from repair shops when ordered in for repairs.

Section 2. Any person, company, corporation or receiver operating any railroad in the State of Minnesota violating any of the provisions of this Act shall be guilty of a misdemeanor, and upon conviction thereof shall be liable for a penalty of not less than $25 nor more than $100 for each offense, and the use of any one locomotive engine prohibited in Section 1 of this act shall constitute a separate offense for every day or part of a day so used, and such penalty shall be recovered in a suit brought in the name of the State of Minnesota in any court having jurisdiction thereof, in any county in or through which such line of railroad may run, by the attorney general of the State or under his direction, or by the county attorney in any county in or through which such line of railroad may be operated.

All fines and penalties recovered by the State under this Act shall be paid into the treasury of the State of Minnesota.

Section 3. This Act shall take effect and be in force from and after January 1, 1914.

Mississippi—1912.

Section 1. That all railroad companies operating or doing business in this State are hereby required to equip and maintain each and every locomotive used by such companies to run on its main line between sunset and sunrise with a good and sufficient headlight which shall consume not less than 300 watts at the arc, and with a reflector not less than eighteen inches in diameter and to keep the same in good condition. The word "main-line" as used herein means all portions of the railway line not used as yards, spurs or side tracks.

Section 2. That any railroad company violating this Act in any respect shall be liable to indictment as for a misdemeanor in any county in which the locomotive not so equipped and maintained may run, and on conviction shall be punished by a fine of not less than $25 nor more than $500 for each offense.

Section 3. Provided, This Act shall not apply to tramroads, mill roads and roads engaged principally in lumber or logging transportation in connection with mills, nor to railroad systems under thirty miles long not running regular night schedules. Nor to any engine the lighting equipment of which shall have failed during the trip if it is shown that the equipment was in efficient and effective working condition when the trip was begun, nor to switch engines going to and returning from wrecks or sent out on main line to bring into a terminal a train, the engine of which has become disabled.

Section 4. Be it further enacted, That all laws and parts of laws in conflict with this Act be and the same are hereby repealed.

Section 5. That this Act shall go into effect January 1, 1913.

Missouri—1913.

Section 1. That all companies, corporations, lessees, owners, operators or receivers of any railroad or railway company operating a railroad or railway in whole or in part in this State, are hereby required to equip, maintain and use upon every locomotive being operated in road service in this State in the night-time, an electric headlight of 1,500 candle power brilliancy measured with the aid of a reflector, and classification signals not less than six candle power.

Provided, That nothing in this Act shall be so construed as to prevent a locomotive engine, whose headlight has become defective while on the road, from proceeding to the most convenient terminal or division point where the necessary facilities exist for remedying such defect: And Provided Further, That the provisions of this Act shall not apply to independent lines of railroad less than seventy-five miles in length: and Provided Further, That the provisions of this Act shall not apply during the first ninety days of a strike of the particular employees whose duties are to repair and maintain electric headlights.

Section 2. Any company, corporation, lessee, owner, operator, receiver or the officer of any company, corporation, owner, lessee, operator or receiver owning or operating a railroad or railway in whole or in part in this State, violating or causing to be violated, the provisions of this Act shall be deemed guilty of a crime, and upon conviction, shall forfeit and pay as a penalty $300 for each separate offense, which shall be recovered in a civil action in the name of the State, and such petition shall be filed by the prosecuting attorney of the county in which such crime shall have been committed and all fines collected under and by virtue of the provisions of this Act shall revert and become a part of the public school fund.

Section 3. It is hereby made the duty of the judge of any circuit court in the State to direct and charge grand juries, when in session, to make special inquiry as to violations of this law.

Section 4. This Act shall take effect and be full force from and after January 1, 1914.

Montana—1909.

Section 1. It shall be the duty of any person, corporation or company operating any railroad or railway in this State, within one year after the passage of this Act, to equip all locomotive engines used in the transportation of trains over said railroad or railway with electric headlights of not less than 1,500 candle power, measured without the aid of a reflector, or other headlights of not less than 1,500 candle power, measured without the aid of a reflector: Provided, That this Act shall not apply to locomotive engines regularly used in the switching of trains.

Section 2. Any person, corporation or company operating any railroad or railway in this State violating the provisions of Section 1 of this Act, shall be deemed guilty of a misdemeanor, and, upon conviction thereof, shall be fined not less than $100 nor more than $1,000 for each offense.

Nebraska—1913.

Section 1. On and after the first day of January, 1914, it shall be the duty of every person, company and corporation, or the receiver, lessee, manager or superintendent thereof, owning or operating lines of railway in the State of Nebraska, to equip, maintain and use upon each and every locomotive engine operated in road service within the State of Nebraska, a headlight of a power that will plainly outline the figure of a man on or adjacent to the track at a distance of 600 feet in front of the locomotive. The visibility herein required is intended to be measured by and under ordinary night conditions and for the sight of a person having the usual visual capacity required of locomotive engineers from their place in charge of a moving locomotive to such distance: Provided, however, This Act shall not apply to locomotive engines running not more than ten miles into the State to complete their runs, nor to locomotive engines used in regular switching service, nor to such engines as may be used exclusively between sunrise and sunset, nor to such engines when going to or returning from repair shops for repairs.

Section 2. Any person, company or corporation, or the receiver, lessee, manager of superintendent thereof, violating any of the provisions of the foregoing section, or who permits this Act to be violated when it is within his official power or authority to prevent such violation, shall on conviction thereof, be fined in a sum not less than $100 nor more than $500 for each offense. The operation of one engine any part of one day in violation of this Act shall be deemed a separate and distinct offense.

Nevada—1913.

Section 1. Every company, corporational lessee, manager or receiver, owning or operating a railroad in this State, is hereby required to equip, maintain, use and display, at night upon each and every locomotive being operated in road service in this State an electric or other headlight of at least 1,500 candle power, measured without the aid of a reflector: Provided, That this Act shall not apply to locomotive engines regularly used in switching cars or trains: And Provided Further, That this Act shall not apply to railroads not maintaining regular night train schedules, nor to locomotives going to or returning from repair shops when ordered in for repairs.

Section 2. All locomotives backing up over any division or district, or portion thereof at night shall be provided with a headlight of the character described in Section 1 hereof, displayed in the direction the engine is moving.

Section 3. Any railroad company, or the receiver or lessee thereof, doing business in the State of Nevada, which shall violate the provisions of this Act shall be liable to the State of Nevada for a penalty of not less than $100 nor more than $1,000 for each offense. And such penalties shall be recovered and suit brought, in the name of the State of Nevada, in any court of competent jurisdiction, in any county in or through which such line of railroad may run, by the Attorney-General or by the county attorney in any county in or through which such line or railroad may be operated.

Section 4. This Act shall take effect January 1, 1914.

North Carolina—1909.

Section 1. Every company, corporation, lessee, manager or receiver owning or operating a railroad in this State is hereby required to equip and maintain and use upon each and every locomotive in operation in railroad service on main lines in this State an electric or power headlight of at least 1,500 candle power, measured without the aid of a reflector: Provided, That only twenty-five per cent of said locomotives not now so equipped shall be required to be so equipped or used by April 1st, 1910; another twenty-five per cent by April 1st, 1911; another twenty-five per cent by April 1st, 1912, and the remainder by April 1st, 1913: Provided, That this Act shall not apply to locomotive engines regularly used in switching cars or trains: And, Further Providing, That this Act shall not apply to locomotive engines used exclusively between sunup and sundown, nor going to nor returning from repair shops when ordered in for repairs: Provided Further, That this Act shall not apply to independently owned and operated railroad companies in this State, whose mileage of road in this State is 125 miles or less, nor to railroads having only lines extending into this State, no one of which is 100 miles in length in this State: Provided Further, The Corporation Commission may relieve from the operation of this Act such locomotives and roads or parts of sections or branches of roads upon which the said Corporation Commission may deem electric or power headlights not advisable: Provided Further, That should an engine start on a trip with the headlight in good working condition, and from some unavoidable cause such headlight becomes disabled and can not be repaired on the line of the road on which such run is being made, there shall be nothing in this Act to prevent said engine from continuing on said trip, and the railroad shall not be liable for prosecutions on account of such failure

Section 2. That any company, corporation, lessee, manager, or receiver violating the provisions of this Act shall be guilty of a misdemeanor.

North Dakota—1913.

Section 1. (Railroads, Employees, Who?) The provisions of this Act shall apply to any common carrier or carriers, their officers, agents and employees engaged in the transportation of passengers or property by a railroad in the State of North Dakota. The term railroad as used in this Act shall include all roads in use by common carriers operating a railroad, whether owned or operated

under a contract, agreement or lessee; and the term employees as used in this Act, shall be held to mean persons who are engaged in, or connected with the movement of any trains. Provided, however, That in passing through or working within the yard limits of any station or terminal a light of lesser candle power may be used.

Section 2. (Steam Locomotives. Headlights.) That from and after the first day of July, 1914, it shall be unlawful for a common carrier, its officers and agents subject to this Act, to use any locomotive engine propelled by steam in moving traffic, or in the transportation of passengers or property within this State, in main line service between the hours of sunset and sunrise, unless said locomotive engine shall be equipped with a headlight of at least 1,200 candle-power of light when measured without the aid of a reflector: Provided, however, That said common carrier may use its switch engines, for switching purpose only without having provided the same with a headlight as herein required, if said carrier shall so determine: Provided, This Act shall not apply to any engine, the equipment of which shall have failed during the trip, if it is shown that the equipment was in efficient and effective working condition when the trip was begun.

Section 3. (Penalty.) That any common carrier or carriers violating this Act, or any provisions thereof, shall be liable to a penalty of $100 for each and every such violation, to be recovered in a suit to be brought by the Attorney General of the State of North Dakota; and it shall be the duty of such Attorney General to bring such suit upon duly verified information being lodged with him that such violations have occurred.

Section 4. (Cumulative, No Repeal.) Nothing in this chapter contained shall in any manner be construed as repealing, or in any manner altering any other Act or part of Acts heretofore adopted by the Legislature of this State; but the remedies herein provided shall be cumulative and in addition to al other requirements now existing in relation thereto.

Ohio—1910.

Section 1. Every railroad corporation operating a railroad or a part of one in this State, shall, on or before the first day of January, 1911, equip each of its locomotives (except locomotives used exclusively in yard service), with a headlight of such construction, and with sufficient candle power to render plainly visible at a distance of not less than 350 feet in advance of such engine, whistling posts, land marks, and other warning signs, and it shall be unlawful, after such date, for any such railroad to use a locomotive (except locomotives used exclusively in yard service) upon any part of its road lying within this State, that is not equipped with a headlight of such construction and candle power as will enable the engineer to see whistling posts, land marks and other warning signs, at a distance of not less than 350 feet in advance of the engine: Provided, That not less than thirty per cent of all the locomotives hereinbefore required to be provided with such headlights shall be so equipped on or before September 1, 1910.

Section 2. The State Railroad Commission shall from time to time inspect or cause to be inspected the headlights of all locomotives found in use on any railroad in this State. On discovering any defective headlight the commission shall report the fact to the superintendent or other officer having charge of the road on which it is found, and the railroad corporation receiving such notice, shall thereupon cause such defective headlight to be immediately repaired, and if so ordered by the railroad commission shall put the locomotive containing such defective headlight out of service until repaired and put in good working order.

Section 3. Any railroad corporation using or permitting to be used on its line in this State a locomotive, in violation of any provision of this Act shall be liable to a penalty of $100 for each violation, to be recovered in a suit or suits to be brought by the Prosecuting Attorney in the common pleas court of the county having jurisdiction in the locality where such violation occurred. Upon duly verified information being given him of such violation such Prosecuting Attorney shall bring such suits. The railroad commission shall give the proper Prosecuting Attorney information of any such violation as may come to its knowledge.

Oklahoma—1907-8.

Section 1. Every company, corporation, lessee, manager or receiver, owning or operating a railroad in this State, is hereby required to equip and maintain and use upon each and every locomotive being operated in road service in this State, an electric or other headlight of at least 1,500 candle power, measured without the aid of a reflector: Provided, That this Act shall not apply to locomotive engines regularly used in switching cars or trains: And Provided Further, That this Act shall not apply to locomotive engines used exclusively between sunup and sundown, nor going to nor returning from repair shops when ordered in for repairs.

Section 2. Any railroad company, or the receiver, or lessee thereof, doing business in the State of Oklahoma, which shall violate the provisions of this Act, shall be liable to the State of Oklahoma for a penalty of not less than $100 nor more than $1,000 for each offense. And such penalties shall be recovered and suit brought, in the name of the State of Oklahoma, in any court of competent jurisdiction, in any county in or through which such line of railroad may run, by the Attorney General, or by the County Attorney in any county, in or through which such line of railroad may be operated.

Oregon—1913.

Section 1. It shall be the duty of every individual, firm, or corporation operating any line of railroad of more than fifty miles of track within this State, to equip within twelve months after the passage of this Act, every locomotive, power vehicle, power car and other equipment used as the equivalent of or in the place of locomotives, except as are used exclusively for switching services in the railroad yard, and not elsewhere, with an electric headlight of sufficient candle power, measured with a reflector, to throw a light in clear weather, that will enable the operator of the same to plainly discern an object the size of a man at a distance of not less than 800 feet, and thereafter to maintain and use such headlight upon every such locomotive, vehicle, car or other equipment, when the same is operated in the night time: Provided, That this Act shall not apply to a gas or gasoline motor car.

Section 2. Any individual, firm or corporation violating any of the provisions of this section shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine of not less than $100 and not more than $500 for each offense, and in addition shall be liable for all damage resulting, in whole or in part, directly or indirectly from such violation.

Section 3. All Acts and parts of Acts in conflict herewith are hereby repealed.

South Carolina—1912.

Section 1. Every company, lessee, manager or receiver, owning or operating a railroad in this State, is hereby required to equip and maintain and use upon every and each locomotive being operated in railroad service in this State, headlights of at least 10,000 candle power, measured with the aid of a reflector, or with a headlight that will enable a man of normal vision to see a man at 800 feet from the locomotive, under normal conditions: Provided, That this Act shall not apply to locomotive engines regularly used in switching cars or trains: And Provided Further, That this Act shall not apply to locomotive engines used exclusively between sunup and sundown, nor going to or returning from repair shops when ordered in for repairs: And Provided Further, that it shall not apply to a case where the headlight of an engine has failed after starting on a trip and cannot be repaired on the line, nor another engine furnished, but such engine may continue on its trip or to such point as it is practicable to furnish a new engine or to repair the said light.

Section 2. Be it Further Enacted by the authority aforesaid that each said person, partnership, companies or receivers who are affected by this law, shall, within one year, equip one-fourth of their respective engines in accordance with this Act, and shall each year thereafter equip one-fourth of said locomotives until the entire number is so equipped: Provided, That all locomotives hereafter equipped by the persons or corporations, receivers or partnerships affected hereby, shall be equipped in accordance herewith.

Section 3. Any railroad company, or the receiver or lessee thereof, doing business in the State of South Carolina, which shall violate the provisions of this Act, shall be liable to the State of South Carolina for a penalty of not less than $100 nor more than $1,000 for each offense, and such penalty be recovered and suit brought in the name of the State of South Carolina in any court of competent jurisdiction, in any county in, or through which line of railroad may run, by the Attorney General or any Circuit Solicitor.

Section 4. All Acts and parts of Acts in conflict herewith are hereby repealed.

Section 5. This Act shall not apply to railways or railroads less than sixty miles in length in this State.

South Dakota—1911.

Section 1. It shall be the duty of every railroad corporation or receiver or lessee thereof operating any line of railroad in the State of South Dakota, to equip all locomotives being operated in road service in the State of South Dakota in the night time, with a headlight of not less than 1,500 candle power measured without the aid of a reflector, the same to be kept in good condition: Provided, That ten per cent of the said locomotives shall be required to be equipped within sixty days after the passage and approval of this Act and an additional ten per cent to be so equipped every thirty days thereafter until all engines operated in the State of South Dakota in the night time in road service shall be equipped according to the provisions of this Act.

Section 2. Any railroad corporation or receiver or lessee thereof operating any line of railroad in the State of South Dakota which shall violate any of the provisions of this Act shall be liable to the State of South Dakota for a penalty of not less than $100 or more than $1,000 for each offense.

Texas—1907.

Section 1. It shall be the duty of every railroad corporation or receiver or lessee thereof, operating any line of railroad in this State, within six months after the passage of this Act, or within such additional time as may be prescribed by order of the railroad commission of Texas, after a proper showing of their inability to comply by the railroad has been made, to equip all locomotive engines used in the transportation of trains over said railroad with electric headlights of not less than 1,500 candle power, measured without the aid of a reflector, or other headlights of not less than 1,500 candle power, measured without the aid of a reflector: Provided, That this Act shall not apply to locomotive engines regularly used in the switching of cars or trains.

Section 2. Any railroad company or the receiver or lessee thereof, doing business in the State of Texas, which shall violate the provisions of this Act, shall be liable to the State of Texas for a penalty of not less than $100 nor more than $1,000 for each offense.

Vermont—1912.

Section 1. A railroad corporation doing business within the State shall equip, maintain and use on its locomotives such headlights and cab lights as the Public Service Commission on notice and hearing shall determine and order. Said Public Service Commission shall within a reasonable time after notice to the railroad companies in Vermont and hearing, make an order with relation to such headlights and cab lights.

Said Public Service Commission shall publish notice in at least five prominent papers in the State, of the time and place of such hearing.

Section 2. A railroad corporation that violates the order of the Public Service Commission made under the preceding section shall be fined not more than $100 nor less than $25 for each day's neglect to obey said order.

Section 3. This Act shall take effect July 1, 1913.

Washington—1911.

Section 66. Each locomotive on every railroad in this State shall be equipped....., excepting such as may be assigned to daylight runs or switching service exclusively, with electric headlights of approved design and capacity (except that locomotives may be operated without such headlight upon permission and order of the commission.) . . . .

Wisconsin—1911.

Section 1. There is added to the Statutes a new section to read:

Section 1809v. 1. It shall be the duty of every corporation operating any steam railroad of more than fifty miles of track within this State, to equip on or before July 1, 1912, every locomotive, power vehicle, power car, and other equipment used as the equivalent of or in place of locomotives, except such as are

used exclusively for switching service or in railroad yards and not elsewhere, with a headlight of sufficient candle power, measured with a reflector, to throw a light in clear weather that will enable the operator of the same to plainly discern an object the size of a man, at a distance of not less than 800 feet, and thereafter to maintain and use such headlights upon every such locomotive, vehicle car or other equipment, when the same is operated at night time.

Section 2. Any corporation violating any of the provisions of this section shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine of not less than $100 nor more than $500 for each offense, and in addition shall be liable for all damages resulting in whole or in part, directly or indirectly, from such violation.

Noting the summary of these laws, as indicated, your special attention is called to the fact that many of the state's laws require that the headlamp shall have not less than 1500 (fifteen hundred) candle power, when measured without reflector. Others specify 10,000 (ten thousand) candle power measured with reflector; others require 300 watts at the arc, while some require that an object the size of a man shall be distinctly seen at certain specified distances; one state requiring a specific dimension of reflector.

Your committee in considering the summary of these laws are of the opinion that they were drawn without due consideration of a suitable standard condition or basis under which test could be made and reproduced, and would recommend that this association express its sentiment as being unfavorable to the enactment of any law or laws which do not clearly specify a standard national basis under which test may be made, which basis may be prescribed by this body (A. R. E. E.), the A. I. E. E., the National Bureau of Standards or a special committee or commission who are properly qualified.

And, whereas, some of the laws, as enacted, tend to preclude the use of more efficient apparatus, and the methods of using the same, which tend to retard the art of invention and application, your committee recommends that it be the sentiment of this organization that if such laws are enacted that standard specifications, as outlined above, be so drawn as not to eliminate apparatus which may be invented or designed in the future. It is the opinion of this committee that the quantity and quality of illumination at some specific point is the prime object and not the means or apparatus by which this illumination may be effected or obtained.

On account of the limited time and means at their disposal your committee deems it impracticable and inadvisable to prescribe a specific basis at this time upon which to work, and would recommend that this matter be referred to a special committee.

CHAS. R. SUGG, Chairman,
J. H. BURCHAM,
F. E. HUTCHISON.

Committee on Wiring for Electric Light and Power in Railway Buildings

Your Committee has prepared a set of specifications governing electric light and power wiring for buildings used for railroad purposes. In preparing these specfications, however, we have taken into consideration the specifications and report submitted by this Committee at the 1912 Annual Convention, which report appears in Volume 5, of the Proceedings, the intent being that these specifications shall be made a part of the 1912 Report which outlines the system of wiring for various buildings.

We have also prepared an outline of specifications for electrical equipment of movable railroad bridges, bringing out as many of the important points in connection therewith as has occurred to the Committee which should form a good basis for the compiling of suitable specifications covering this work.

This Committee realizes that the specifications as presented may not fill the requirements and conditions of all railroads, but nevertheless, the specifications will form a good foundation from which specifications covering any class of work may be made.

The specifications following are respectfully submitted for your consideration.

(Signed.) A. J. FARRELLY, Chairman.
C. R. GILMAN.
A. S. SCHULMAN.
C. J. CAUSLAND.
JOS. A. ANDREUCETTI.
W. J. BOHAN.
A. L. CHAPIN.

OUTLINE OF SPECIFICATIONS FOR ELECTRICAL EQUIPMENT OF MOVABLE RAILROAD BRIDGES.

The first thing to be considered in furnishing electricity for a movable bridge is its availability. In some places it will be found that available current is too far from the bridge site and the expense very heavy to bring it to same. Under these circumstances it is up to the engineer to decide on the advisability of installing a local power plant: Gas engine driven generator and storage battery. Bridge to be operated directly from storage battery and the storage battery charged from gas engine driven dynamo.

In smaller installations where storage batteries are not required, gas engine operating the bridge direct, may be used.

Service and Nature of Current:

Where current is available, the first thing to be determined is the most practical way to bring same to bridge site. Where high tension alternating current is available, it is preferable to bring the high tension current to the bridge site, installing the transformer nearby and carrying the low voltage current to the switchboard in the operator's house. With A. C. current available, it is possible to bring electricity from greater distances than when direct current is available. With the latter, 600 volt direct current is found to be most frequently available. The zone in which this can be economically carried to bridge site is distinctly limited, but when it can be economically brought to the bridge, this voltage is usually used direct on the motors and lighting system.

Types of Bridges to Be Served:

There are in present use, three distinct types of movable bridges: The draw-bridge, which swings on its pivot pier; the bascule bridge or jack-knife bridge; and the vertical lift bridge. On all three types the bridge engineer usually furnishes the Railroad Company with the size of motor necessary to operate their particular structure. The part usually falling on the Railroad Company's electrical engineer, is the bringing of the current to the bridge. With the draw bridge it is usually brought to the nearest rest pier, and with the bascule bridge it is usually brought to the switchboard in the operator's house, while with the vertical lift bridge it may be brought to the base of the towers on either side of the river. From the switchboard on, including all equipment, the work is usually handled by the bridge company or electrical contractor.

Motive Power on Bridges:

The types of motors used on a bridge is usually of the Railway or mill type of motor, and further depends upon the kind of current available. The size of motors depends upon the weight of the structure, which is always specified by the bridge engineer. All motors are equipped with solenoid brakes.

Control:

The system of control of an electrically operated bridge is perhaps the most important feature of the entire installation. Direct operated drum controllers are desirable up to about 50 horsepower. Above 50 H. P. it becomes a question as to whether remote control should not be used, and should the voltage be 220 or lower, remote control can be used efficiently. With remote control the contactors can be mounted close to the motor and the master drum located in the operator's house. On all small installations under 50

H. P. the Street Car type of drum controller is preferable; that is, with a separate handle for reversing. This gives the operator time to think of what he is going to do before he reverses the operation of the bridge.

All motors on a bridge should be electro-mechanically interlocked so that each operation must be handled in sequence, and it will be impossible for the operator to operate any motor out of sequence. The system of interlock should also be interlocked with the Railroad Company's track interlocking machine so that it will be impossible to raise the bridge until all track signals have been set to danger.

Air Equipment and Brakes:

It is extremely desirable in all installations to install a small motor driven air compressor. This air compressor is to be used to fill an air tank from which air brakes and whistle are operated. These air brakes are frequently used as emergency brakes, should the electric brakes fail to work. The two styles of brakes are extremely desirable on all movable bridges. The air can further be used for the pumping of gasoline from the track level to the operator's house where an engine driven generator is mounted.

Cables and Wire:

In the draw type of bridge, it becomes necessary to transmit the current from the rest pier to the center pier by means of submarine cable. The moving of the bridge is dependent on this cable, consequently it cannot be too well made. A 30 per cent para rubber insulation should be used with a substantial wall of lead and galvanized steel wire armor. The submarine cable should be substantially clamped to the piers so there is little danger of their being injured from vessels moving in the channel.

All wire on a movable bridge should be of such a size that it will carry the current with no more than 5 per cent drop when motors are operating at full capacity, and on the lighting circuits not more than 3 per cent drop when lines are fully loaded. Due to the vibration and out-door service all wires should be insulated with 30 per cent pure para rubber, double braid and of the thickness of insulation as specified in the National Code for the respective sizes. No joints should be made in the pipe and where joints are necessary, cast iron junction boxes should be installed.

It is not desirable to ground wires on railroad bridges. All circuits should be of a complete metallic return to the switchboard.

Conduit and Fittings:

All conduit should be preferably of the galvanized make and amply large so that wires can be drawn in free from mechanical abrasion. All joints should be thoroughly leaded with white lead on making up the pipe. All fittings and junction boxes should be of cast iron and with plumbers' lock nuts and rubber gaskets. All conduit should be drained at all low points of the line so that any moisture collecting therein can be drained off.

Switchboards and Instruments:

Switchboard of sufficient size to carry all instruments necessary for the operation of the bridge is to be supplied. It is not desirable to use a current of over 550 volts A. C. on bridge work and not over 600 volts direct current. At these high voltages it is preferable to use marble instead of slate, unless slate can be procured which is absolutely free from metallic streaks. The switchboard should be located at a convenient point in the operator's house so that it can be in the direct view of the operator at all times during the operation of the bridge.

The instruments should be graduated with a scale sufficiently large to be easily read across the room. The recording ammeter or watt-meters are to be installed when an exact record of the number of openings of the span is desired. The charts from these instruments are authentic as to the number of operations. In the development of the art of electrical equipment on bridges, it has been found that the solenoid contactor with its overload coil, is preferable to the circuit breaker, in that the operator does not have to leave his controller stand to reset a circuit breaker. This is true for all motors used in the operation of a movable bridge.

Lighting and Signal Indication:

The lighting of a railroad bridge is not extremely important. The only lights that are required are about the machinery and in the operator's house, and the latter are usually turned off when operator desires to operate the bridge. The signal indication is very important as this gives correct indications of the various movements of the rail locks, the swinging of bridge, or of the motion of the end lifts, and should be very carefully installed and maintained at all times. The wiring for same must be done very carefully, and each wire tagged for its respective purpose. The navigation lamps as adapted by the U. S. Government must be strictly observed. These rules are given under a bulletin issued by the War Department and can be readily obtained.

Conduit.

All wrought steel pipe or tubing must have a nominal diameter as called for by the schedule, and to be what is known as full weight standard pipe. In each instance an inside diameter and thickness of wall is shown in the following details:

Nominal Diameter. Inches.	Actual Inside Diameter. Inches.	Thickness of Wall. Inches.
½	.62	.10
¾	.82	.11
1	.04	.13
1¼	1.38	.13
1½	1.61	.14
2	2.06	.15
2½	2.46	.20
3	3.06	.21

Conduits must have smooth interior surfaces, free from all seams and burs, and must be galvanized or sherardized.

All threads on conduits to be carefully cut with the threads concentric with the bore and of sufficient length to accommodate all couplings, locknuts and bushings in connecting the conduits together or to the various cabinet, junction and outlet boxes.

All conduits must have the maker's name or trademark and the label of the Underwriters' Laboratory stamped upon each length.

Bends.

At all bends or changes in direction use elbows made of the same tubing as the conduit, curved to long radius, or bend the conduit itself to a long radius; in either case the bend shall be made in such a manner as not to flatten or in any way contract the bore of the conduit, nor injure the coating of same.

Joints.

The ends of all conduits and elbows shall be cut off true and square, and after being properly threaded shall be reamed so as to leave a smooth rounded or beveled edge at the junction of end face and bore of tube, all joints to be made watertight, using standard galvanized or sherardized iron couplings with the ends of the conduits brought tight together. All joints in conduits that are to be laid in damp, moist or wet floors shall be made perfectly watertight with red or white lead.

No conduit containing any circuit or circuits shall have more than four bends between the panel board box and the first outlet. In each case where more than four bends are required in any run of conduit a pull box shall be inserted for other bends.

Outlet and Junction Boxes.

For all outlets in dry buildings where no watertight conduits system is required, pressed steel boxes shall be used. These boxes shall be not less than No. 12 gauge material and must be thoroughly sherardized or galvanized. All outlet boxes must be provided with holes for supporting same, also holes for screws supporting fixture studs. In buildings subject to moisture of any description, only cast iron outlet boxes shall be used. For outlets from ceiling, outlet boxes without threads can be used, but for wall outlets the boxes must have threaded connections and all joints must be made with either red or white lead. For switches, receptacles and plug outlets, the same class of construction will be required.

Conduits entering outlet boxes shall have a lock nut on the outside of the box, and only sufficient thread for a bushing inside of the box. The same arrangement holds good where conduits enter panelboard boxes as well as junction or pull boxes.

For all ceiling fixtures in fireproof buildings, an independent fixture support shall be furnished, and under no circumstances shall a fixture stud be depended on as a support. The fixture support can be made of ⅜-in. iron pipe, flattened on one end and a long running thread on the other end. The flattened part of the ⅜-in. pipe can then be formed into an eye to receive a ½-in. or ¾-in. conduit for a crossbar, which will then rest on the fireproofing above. The long running thread in the outlet box is for the purpose of receiving a ⅜-in. locknut on both sides of the box, which will also serve as a support for the box where conduits are being arranged for same.

Floor Outlets.

Where electric light or any other outlets are required in the floor, cast iron boxes shall be used for such a purpose.

They shall be provided with threaded connections and the joints shall be made watertight with either red or white lead. Each box shall be provided with a floor leveling arrangement. In all cases a floor plate with a flanged ring shall be provided for the protection of the floor when inserted in concrete or tile. If floor box is used for electric light purposes, it should be arranged to contain a plug receptacle of the standard make. All finished floor plates shall be provided with nozzles according to the use it is intended for. All fittings must also be provided with rubber packing to make the box watertight.

Where floor outlets are required for telephone, telegraph or push button or fire alarm systems, time clock, stamp and other purposes of this kind and outlets are required alongside of each other under a desk, a sectional floor box should be provided for such a purpose, and each system should have a separate connection independent of each other. The construction of this sectional floor box must comply to floor box described above.

All conduits, bends, connections and fittings shall be carefully examined after being delivered at the building, and again before being installed, and all material that does not conform to this specification in quality of material or finish shall be rejected and removed from off the premises.

No conduit larger than ¾ in. inside diameter shall be used on the branch distributing circuits, and not more than two duplex No. 14 wires or five single wires No. 14 shall be drawn into it. One-half inch conduit shall have one duplex or three single wires No. 14, or one duplex and one single wire No. 14 drawn into it.

Supports.

All conduits shall be properly supported when used as vertical risers or in a horizontal run. Each support shall be not less than four feet apart on horizontal runs, and consist of clamps secured to the floors of buildings by means of expansion or toggle bolts. Where conduits are built in concrete floor structures they shall be so located as not to reduce the strength of concrete slabs. No conduit shall come in contact with or be fastened to any other pipes in the building. Where conduits are used for vertical risers they shall be supported every 35 feet, and all of these supports shall consist of cable racks with pull boxes. Where conduits terminate at the pull box, the insulated cable shall be supported on porcelain clamps in these pull boxes. All conduits in every class of construction shall form a continuous metallic connection from outlet to outlet, and to panel boxes.

Conduits used for open or visible work shall be supported in a like manner as called for above, but in no case shall nails be used for pipe straps or other supports, and all fittings shall be supported with either wood or machine screws.

In all classes of construction conduits shall be thoroughly grounded in a manner as called for by the National Board of Fire Underwriters, except in fireproof steel structures. Where conduits are in direct contact with the steel structure no extra grounds will be required.

Pull Boxes.

Where conduits and feeders are to be supported on horizontal runs on the ceiling, a pull box should be inserted at least every 150 feet. In case of angle bends or turns, it is recommended that long sweeping bends should be made, especially where cables heavier than 4/0 are to be used. It may also be advisable to use a pull box to relieve the strain of pulling cables. All large pull boxes shall be arranged for porcelain supports so the weight of the cable will not bear down on the covers in such box. All pull boxes should be made in sections and put together with screws or bolts, and not with rivets.

Cabinet Boxes.

Cabinet boxes shall be made of No. 10 gauge sheet steel and to be of a built up type of construction, properly stiffened with steel angle iron corners thoroughly riveted together and provided with the necessary lugs, etc., to support the panel lining. The front to be made from a single sheet of steel with door opening in same, leaving a frame of proper width all around. The door to be made of a single piece of steel, carefully fitted to its frame, and closing type against suitable rabbeted strips to be properly stiffened and hung on heavy pressed steel hinges. For panels from one to ten circuits the doors shall be provided with spring hinges; for panel boxes over and above ten circuits the doors shall be provided with self-locking bolts and nickel-plated vault handle, and all doors for panel boxes to be provided with Yale locks and duplicate keys.

Wiring.

Before any wire is drawn into any conduit system the following must be observed:

First—On the ceiling work no wire shall be drawn in pipe until building has received at least its first coat of plaster.

Second—All conduits must be free from moisture or water that may have gotten into the pipe either from bad joints in pipe or condensation; then the conduit should be saturated with soapstone and wires drawn into same. Under no consideration shall oil or grease be used for either branch circuits or cables to be drawn in the conduits.

Where wires are drawn for branch circuits there should be eight (8) inches of wire left at either the ceiling or bracket outlets, and at least twelve (12) inches of wire left in the panel box over and above that required to go under a binding post or terminal on the panel board.

On wires in sizes, No. 10 to No. 14, nothing but hand labor shall be used to draw them in the conduits. On cables heavier than No. 8, block and tackles may be used but the cables must not be submitted to undue strain so as not to injure the insulation.

Splices of wires to be made as follows:

Care should be taken to remove the rubber compound from the copper, but in doing this be sure that the insulation is not cut with a knife at a sharp angle to the wire, to prevent cutting the wire in itself, so that when bent under a terminal or for the purpose of making a splice, the wire will not break, but remove the insulation in a tapering manner, the same as you would sharpen a pencil, also be sure that the tin on rubber-covered wire is not scraped off the wire by cleaning the insulation, as this will then protect the copper from corrosion, splice should then be made in a substantial manner and carefully soldered, the acid or paste washed off and the joint dried before tape is applied, then two coats of a high grade rubber compound shall be wrapped on this joint (the compound should be carefully stretched before applying same), then one layer of cotton tape applied over the rubber compound, and on cables larger than No. 4 the ends of the cotton tape shall be tied with a thread so they will not become loose, but in all cases the cotton tape will receive two (2) coats of insulating paint before the joints are left.

All wiring should be arranged for not more than 500 watts in any one branch circuit in fireproof buildings, it is also desired that ¾-in. conduit shall be used between the panel board and the first switch outlet or ceiling outlet, and that no more than one (1) branch circuit be placed in this ¾-in. conduit when the work is designed or executed. This will then permit increased capacity if desired. When cables are used as feeders in fireproof or office buildings in vertical positions, the ends of cables should be supported in strain insulators and turnbuckles, so that slack in the cable can be taken up any time, and not be exposed to the danger of grounding at the bottom of shafts or elbows. Where taps are taken from cables for the purpose of branch wiring, when the feeders are larger than No. 4 B & S, the branch or tap wire should be threaded through the cable and soldered, etc., and not wound round on the outside of the cable.

Where a tap circuit is taken off a feeder to supply current to a panel board, and the main feeder is within 3 ft. of the lugs of this panel board, all such tap wires should be at least 25 per cent larger than the entire capacity of the panel board.

For alternating current, wires of branch circuits or feeders should be placed in the same conduit whether for power or lights. For power wiring the same general specification shall govern as for lighting with this exception; that for power purposes it is desired to divide the system in center of distribution, and concentrate the fuses controlling the various sub-feeders and branch circuits in one place. This however will not prohibit the use of a sub-feeder controlling 3, 4 or 5 h. p. motors on one main fuse, and taps taken from this sub-feeder to each 5 h. p. motor and the fuses placed near the motor, providing the tap wire is the same size as the sub-main. It is also preferred to provide circuit breakers on power distributing panels instead of fuses for feeders supplying over 10 h. p. Circuit breakers can be placed at the main distributing panel the same as fuses.

Panel Boards.

Panel boards may be made of either slate or marble. In either case materials should be selected that are free from metallic veins of any description. The slate or marble for panel boards of 10 circuits or less should be at least 1 in. thick, and for over that number of circuits should be at least 1½ in. thick. All panel boards should be provided with a four (4) inch gutter all around. All side linings should be at least ¾ in. thick. Side lining should be provided with slots for branch wires leading from the gutter to the branch circuits, and no holes shall be drilled in side liners for branch wires to be drawn through them for the purpose above indicated.

All slate and marble panels shall have at least a ¾-in. space between the back of the panel and the sheet metal frame for the purpose of air ventilation, when panels are placed either on or in brick walls exposed to outside air contact. All marble or slate panels including linings shall be supported on iron frames or boxes and shall be supported with machine screws or studs,

and holes in all work shall be threaded but no nuts shall be used at the end of board where they cannot be gotten at from the front.

Panel boards should be provided in all cases with substantial busbar work. Busbars whether for vertical or horizontal runs or for main feeders or branch circuits shall not be less than 3/16 in. thick, in order to have a sufficient number of threads for screws that may form a contact or support between any two busbars. Busbars placed on panel boards shall be arranged so that they can be removed from the front of the panel board without removing this panel board from its iron box or support. This can be done by means of using screws with nuts countersunk in the rear of the panels and these nuts leaded in the countersunk holes. This arrangement shall also be applied to parts of switches, fuse blocks and fuse clips.

Branch circuits on panel boards shall be provided with knife switches of 25-amp. capacity each, also with plug or cartridge fuses. On the hinges of branch switches, threaded studs with spring washers and nuts shall be used. Rivets on these hinges will not be permitted. All screw heads used on the surface of busbar work for panel boards shall be proportioned to the lift of the busbar they serve so that larger busbars shall have large proportioned screw heads to give it a substantial appearance. All panel boards should be provided with a main switch and main fuses to control the total capacity, also receptacle with either plug attachment or lamp base for inspector's use, and in all cases these receptacles shall be connected to the switch terminal, also have fuses provided so that in case the main switch of the panel board is open, light can be had from this receptacle for the purpose of doing repair work in and around this panel. On the larger installations where there is a three-wire system used for feeders, it is preferred that two receptacles be used in each panel board and connected to each side of the three-wire system, and these receptacles connected to a different set of mains than that in the respective panel board, receptacles are installed in.

All switch handles whether for branch or main fuses shall be of the spade handle type and for the switches below 50-amp. shall be made of compressed fibre, and for switches over 50-amp., they can be made of hardwood saturated in a waterproof compound. On larger switches it is also desirable that the spade handle shall be bolted to the cross bars and under no consideration shall the switch blade serve as a terminal support for a spade or any other kind of handle.

Slate panels described above shall only be used up to 440 volts. For larger voltage blue Vermont slate is preferred.

The above specification shall govern all classes of electrical work in buildings used for railroad purposes, and where anything special is required, the following conditions must be followed:

In round houses, the conduit shall be placed below the smoke line, either on the outside or on the inside of the outer walls directly above the windows. If conduits are placed on the outside of the wall and taps are taken through this wall for branch circuit purposes, a water-tight junction box shall be placed at this point, and fuse terminals with fuses in a cast iron box shall be placed at the bottom of such a tap circuit. Tap circuits shall also be of the same size as the outside main. If the conduits are used for any purposes underground, they shall be placed at least 12 in. below the finished floor and imbedded in concrete. Where conduits enter the floor or are brought out of the floor to wall above, there shall be a cast iron casing put over the conduits and this casing extended 6 in. below and above the finished floor line.

For the general illumination of a round house, a cluster of tungsten lamps with porcelain enameled reflector will better serve the purpose, but this part of the work will have to be determined by each individual case. For plug receptacle outlet boxes, nothing but cast iron fittings with threaded connections shall be used. In all cases the work should be made as watertight as can possibly be done.

Conduits placed on walls either inside or outside ofthe building should have a space between the conduit and the brick wall to reduce condensation to a minimum. In all cases, however, no pocket shall be left in the conduits where the condensation would form into water, but should be arranged so it will invariably drain to the fittings.

In boiler rooms, conduit should be kept below the line where temperature and smoke may have an injurious effect on the conduit or the insulation of the wire. It is preferred that the main supply should be run not over 15 ft. above the floor, and branch circuits taken off of this main for the various groups of lights used for general illuminating purposes. For lights used to illuminate water and pressure gauges, conduit should be run on top of the brick work of the boilers, and a fireproof insulated wire shall be used in these branch circuits.

Individual lights shall be suspended on rigid pipe brackets in the rear of the boiler, and separate circuits shall be run for general illumination, also for a receptacle at the rear of each boiler for extension cords.

In engine rooms, the work in general shall be done in the same manner as in boiler rooms, except where individual lights are supposed to be erected on and around frames of engines, all conduit work shall be started from the top of the engine and the branches run down. All fittings and joints to be made waterproof to avoid oil seeping inside of the conduits.

In machine shops the work in general will have to be laid out as best adapted for the class of work to be done in these shops. For general illumination and for power, feeders should be brought to main distributing centers and from there, subfeeders or branch circuits shall be run to the various outlets, the object being; the fuses or circuit breakers controlling subfeeder or branch circuits should be concentrated as much as possible and not be scattered throughout the building. For illumination, large tungsten units are best adapted, except that individual receptacles with extensions should be provided at each machine for general use around the work.

For power purposes in machine shops it is preferred that each motor should be controlled by individual mains, but two or three small motors can be connected or supplied by one subfeeder, and taps taken from this sub-feeder to each individual motor should be the same size as the sub-feeder in itself, and in addition to fuses or circuit breakers in the main distributing panel, it is necessary that a circuit breaker must be located at each machine tool operated by an electric motor, and this circuit breaker should be controlled by one or more push buttons placed on this machine tool, usually accessible to the operator for the purpose of immediate and quick opening of the circuit in case of emergency. Circuit breakers should be enclosed in iron boxes set on pedestals, columns or walls as conditions may require, and each iron box shall have a door with hinges on the left side.

Extension cords, for machine shops, engine rooms and boiler rooms should be of flexible metallic encased conductors with either Hubbell or other stage pocket attachment, wood handle, key socket and wire guard.

Main feeders for power in machine shops should be at least 70 per cent of the aggregate capacity of the motors connected or to be supplied by this feeder. Branch or sub-mains should be at least 100 per cent of the capacity of the individual motors they are supposed to supply.

For alternating current, feeders should be at least 200 per cent larger than the motors they are supposed to serve.

For coal sheds and chutes open conduit work should be used. Cutouts should be placed in rooms not subject to coal dust or moisture. Pendants supporting sockets or lamps shall be made of rigid pipe. Sockets and lamps should be protected by waterproof outer globes. Switches controlling lamps should be placed in rooms free from coal dust or moisture.

For cinders and ash pits wires should be run open from the nearest building supported on poles, and brackets furnished to support the socket, lamp and reflector. The lamp is to be placed about 18 ft. from the ground at an angle of 45 deg. Size of the lamp bracket and reflector to be determined by the purpose they are to serve.

Passenger stations and platforms for same shall be grouped in the manner described above for fireproof and concealed work.

For freight stations and loading platforms open conduit work can be used, inside of the freight house, the conduits can be run on rafters alongside of the walls and branches for the various outlets taken from these mains and carried over the long rafters to the center or point where the outlet is required. In no case shall conduit be run from rafter to rafter having open space between where conduits would be exposed to injury by freight handlers. Service and distributing centers shall be placed in offices of freight stations, and not in the freight house proper, so that all fuses, switches, meters and other controlling devices should be out of the way from any possible injury by freight handlers or other elements.

On lights for loading platforms, all work should be considered as weatherproof, and for that purpose, all fittings should be cast iron, threaded connections, and made water-tight with red lead. In addition to the general illumination of loading platforms, plug receptacles should be provided at least every 30 ft. for extension cords to be taken inside of freight cars, but the plug receptacles should be connected to a different circuit than that furnishing the general illumination of the loading platform. It is furthermore very essential that no more than 5 receptacles shall be placed on any one circuit.

On all work described in the above specifications, for the details of construction and the general selection of materials, the National Underwriters' rules shall be considered part of these specifications.

Committee on Terminal Facilities in Maintaining of Electric Lighted Cars

Your committee on this subject has been unable to detail this report complete on account of the many conditions that exist at the different terminals which this committee has inspected.

Battery Houses.

Battery houses should be well lighted both by glass in the walls and also through skylights if the conditions permit. Benches for holding batteries should be arranged so that they are the same height as the top of the battery trucks which in turn should be the same height as the yard platform to the floor of the battery box on the car. These benches should be arranged so that there is nothing above them and they should be well-painted with approved acid-resisting paint.

Floor should be of vitrified brick laid in asphaltum or an asphaltum floor not less than 3 inches in thickness laid in such a form that any water may be carried off to either side. There should be doors on the outer walls between the rows of benches of sufficient width to permit the easy handling of a truck load of batteries. Wires for charging the batteries should be run overhead in conduit with drops so located as to readily permit connecting up of the sets of batteries for charging. All conduit work should be done in a manner as outlined in the "Committee on Wiring for Electric Light and Power in Railway Buildings."

The wash-bench and the wash-tables should be approximately the same height as the other charging benches and should be covered with not less than 20 lbs. sheet-lead. The wash-bench should have a trough provided with an overflow which should drain into a box or sump which in turn should be provided with an overflow and from this drain into a second box or sump which should also be provided with an overflow; this overflow being so arranged that the water will rise to a certain height in the water trough or box before overflow into the necessary box, this, with the idea of catching all the sediment which would be washed out of the batteries. From this last box, connection should be made to the sewer through vitrified tile pipe or lead-pipe not less than 3 inches in diameter.

The wash-bench should be placed so that it will run at right angles to the storage or charging bench. The lead burners' bench should be in a separate room on account of the State Factory Law in the State of Illinois requiring that all lead manufacturing should be done in separate rooms. This lead burners' room should be partitioned off conveniently to the wash room and with plenty of light and natural and artificial ventilation. Water-still should be installed for the purpose of obtaining distilled water for the flushing of batteries and the mixing of electrolyte. An underground and overhead tank should be provided for electrolyte, these tanks to be made of sheet led, the acid being dumped from the carboys and forced by air pressure into the overhead tanks and from there run by gravity through the cells as required.

Generator room or switchboard room, if there should be one, should be placed at the end of the building, same can be located on the second floor. Under no consideration should a generator or switchboard room be located in battery cleaning room without a party wall closing off the battery cleaning room proper from the charging plant.

Provision for wash-tanks should be made at the wash-bench by means of a washhouse attached to an overhead outlet, the water being turned on and off by Butterfly valve operated by a pull-chain or rod.

Steam should be available not only for heating the building but also for softening the sealing compound from the covers and for softening compound around the tanks, the latter in order to remove tanks in case of leaking or renewal of trays.

Air should be provided for lead burners' purpose, being carried through reducing valve in order to cut down the air pressure to the desired amount. A "Safety" gas regulator is recommended as a very good reducing valve for this purpose, very easily installed and can be obtained at practically all railroad terminals without any disadvantage. Battery house should also be provided with adequate facilities in the way of lavatory equipment. This lavatory equipment should consist of suitable wash basins and shower baths, the latter is necessary in order to comply with the Illinois State Factory laws for this class of work. Suitable lockers should also be installed, so that the working clothes for the men can be kept in separate compartments from their street clothes, the latter is also required by law of the State of Illinois to meet the State Factory Laws on this class of work.

The pipes carrying water, air and electrolyte for this class of service should be run overhead on account of the hazard of acid deteriorating metal pipes, and any damage that may exist could readily be detected and easily repaired at any moment.

Tools Required.

One 14-inch air brake cylinder mounted as a press to be used for straightening warped or buckled plates.

One gas generator outfit, or if preferable, tanks or hydrogen and oxygen, can be purchased.

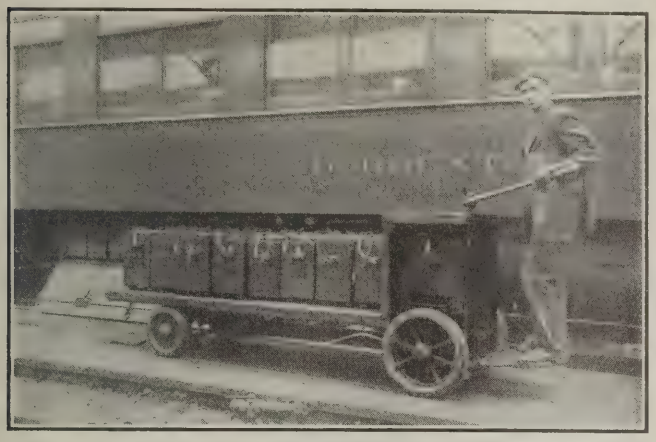
Several sets of burning tools, that is, rubber hose "Y" connection cocks, and burning tips of various sizes, whatever forms may be convenient for holding the material while burning same so as to get the product uniform.

From a point of safety 4 or more electric soldering irons is recommended to take the place of charcoal pots, gasoline stoves, and gasoline blow torches to eliminate fire in the battery house. Committee would also recommend that gasoline torches or gasoline furnaces should not be permitted to be used in any buildings unless absolutely necessary, where electric current cannot be obtained to operate an electric soldering iron. Sealing compound can be heated by electric melting pots, charcoal furnace, or gasoline furnace. Committee feels that electric furnaces are more preferable. Hot water tanks should also be provided in the battery house for softening hard rubber covers in order to straighten same when they become buckled or warped from constant use. Paint brushes of various sizes, stencils, screw drivers, hammers, cold chisels, lead scrapers, combination pliers, side cutting pliers, putty knives, Porter wire cutters No. 8 tin snips, hand saws, hack saws, ratchet braces and twist drills should also be provided. The Illinois State Factory Law makes it compulsory that the employer furnish and maintain the proper working clothes, such as pants, coats, rubber gloves and rubber boots, to the men engaged in the handling of lead.

Battery Trucks.

Several forms of trucks, chiefly hand-power trucks, are now in use. One of the railroads are using motor-driven trucks for the transporting of batteries and dining car supplies. These trucks were originally designed for warehouse service but have proven to be an enormous success in handling large number of sets of batteries that is required in most terminal yards. The only objection we have to them is their height, which necessitates lifting the batteries out of the battery box on the

car to the truck and from the benches in the battery house when the batteries are taken off the car, and vice versa and when the batteries are applied to the cars, which is all useless labor and could be eliminated in a truck de-



Battery Truck for Handling Car Lighting Batteries.

signed with the proper height. Designs for special battery trucks are under consideration and will probably be taken up at some future date. Some idea can be obtained of the nature of the truck by the above cut. Charging outlets may be provided on all tracks, so electric lighted cars may be charged at any point throughout the yard. This arrangement can be met with several different forms or schemes of wiring.

Electricians repair shop should be provided, annexed to battery house is preferable, but is not compulsory. Machine tools should be provided in such shops that require same as follows:

One 12-inch engine lathes.
One 36-inch draw cut shaper.
One band saw.
One radial drill press.
Suitable benches with swivel vice attached.

The above equipment is being known as machine shop tools and should be considered as an axle device equipment for repair shop and under the jurisdiction of the foreman in charge of axle device and battery equipment on electric cars.

A. McGary, Chief Elec., N. Y. C. H. R. R. R.
B. Pachaly, Chief Elec., C., R. I. & P. R. R.
G. B. Colegrove, Chief Elec., I. C. R. R.
W. C. Kershaw, Elec. Foreman Sunnyside Yard, Pennsylvania R. R.
C. J. Causland, Chairman.

WESTINGHOUSE EQUIPMENT ORDERED FOR N. & W. RY. ELECTRIFICATION.

For use in connection with the electrification of the Norfolk & Western Railway, which has been previously announced, the Westinghouse Company has received orders for the following power station apparatus: Three 9,000-kw., 25-cycle, 11,000-volts, 1,500-r.p.m., single-phase, turbo alternators, with two 150-kw., 250-volt, turbo exciters and one motor generator exciter of the same rating; one 200-kva. O. I. S. C., 3-phase, 25-cycle, 11,000/440-volt transformer; three 1,500-kva. O. I. S. C., single-phase, 25-cycle, 33,000/11,000-volts auto transformers and six 2,500-kva., and four 3,000-kva. auto transformers of similar characteristics; one 10 per cent reactance for the 11,000-volt feeder circuit and one type TA voltage regulator for the turbo-generators.

THE NEW "UNITY" FIXTURE.

The Adams & Westlake Co. have recently developed a new line of fixtures to meet the special requirements of railroad service. This fixture, as its name "Unity" indicates, is a special one-piece fixture as will be noted from the accompanying illustrations. The base, stem, canopy, socket support and reflector are all cast in one solid piece. Two lugs are cast on the inside of the reflector canopy and these are machined and threaded to receive the screws which hold the lamp socket in place. In case it is necessary to renew the wiring at any time, this can be done as simply as in any conduit scheme.

The units for baggage and postal cars are shown in the accompanying illustration and these are made of cast aluminium so as to be as light as possible. The inside of the reflector is machined down to a good reflecting surface of pure aluminium but is not polished. This is, in itself, is a good reflector but if it becomes tarnished at any time, it can be easily painted with aluminum bronze which renews its reflecting properties.

This fixture is also made in larger sizes for freight

New "Unity" Fixtures a One-Piece Aluminum Casting. Section Is Cut Away to Show Lamp Position.

houses, yard platforms, etc. ,and a special unit of the headlight type has been made up for roundhouse lighting. This is equipped with a glass door to prevent smoke and gas tarnishing the reflection and is designed to be placed on the side walls.

U-S-L PRESIDENT GOES ABROAD.

Pressure of business requiring his immediate attention in England and the Continent caused Mr. J. Allen Smith, President of The U. S. Light & Heating Co., manufacturers of the U-S-L Electric Starter and Lighter, Storage Batteries, and Electric Car-Lighting Equipments, to start on his second trans-Atlantic trip of the year on the 11th of this month. Mr. Smith will not only attend to unfinished and new business but will endeavor to visit the various automobile shows, which are held earlier in England and Europe than in this country.

As a result of Mr. Smith's first trip, the officials of the more prominent automobile and railroad companies abroad are now familiar with U-S-L products.

New Reflector Envelope Unit for Car Lighting

It has for some time been an established fact that in order to obtain high efficiency and accurate light distribution by means of a reflector, a specular reflecting media must be used for the reflecting surface. This has been proved both in theory and in practice. It is also unquestioned that efficiency and accurate light control are more valuable assets in car lighting than in any other branch of illuminating engineering, for the battery load must be kept as low as possible.

There are only two specular reflecting media available for use in reflector construction. These are mirrored glass and prismatic glass. While there are many places where mirrored glass reflectors are very useful, their opacity makes them unsuited to passenger car service. The prismatic glass reflector remains as the best means of obtaining high efficiency and accurate light control.

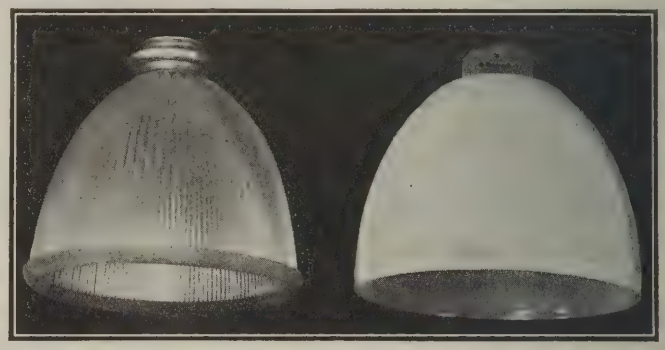
New Reflector Envelope Unit Made Up of Prismatic Reflector With Opal Envelope as Shown Above at the Right.

Although prismatic reflectors are being widely used for car lighting service, some object to it for the following reasons: To some, the appearance of a prismatic reflector is not pleasing—this consideration often outweighing its undoubted superiority as a reflector. There is also the question of ease of maintenance. It is obvious that a prismatic surface cannot be dusted off as easily as a smooth surface. Ignoring the question as to whether or not the proper way to clean *any* reflector is to take it down at definite intervals for a thorough washing, the difficulty of dusting is an objection. (It might be said in this connection that the statement that prismatic glass, *collects* dust is absurd on the face of it. In fact it does not show a dust deposit as soon as will a smooth surface.)

To overcome these objections to a prismatic reflector, and at the same time to retain its advantages, a new unit has been developed. The type of construction has already been applied to enclosing glassware for car lighting service. It has, however, never been used for an open mouth reflector.

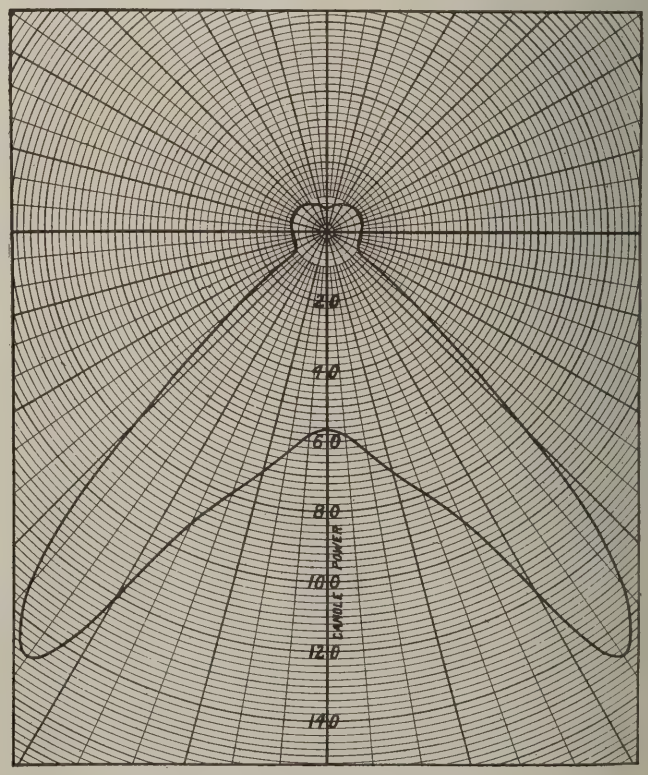
The construction of the unit involves the use of a prismatic reflector designed to give the proper distribution of light for the location in which it is used. Surrounding the reflector, and entirely covering the prisms, there is a smooth surfaced diffusing media, to break up the high lights from the prisms and give a soft diffusion to the transmitted light. The reflector and envelope are so sealed together that no dust can deposit upon the prisms. The complete unit is arranged to apply to or remove from any fixture designed for standard reflectors.

By referring to the illustration it will be seen that the prismatic reflector for this unit has a flange molded



The Two Parts of the Envelope Unit. Note the Sealing Gasket at Lower of Edge of Prismatic Reflector.

on the lower edge, which supports a rubber gasket. The heel of the reflector has a metal extension spun solidly upon it, this extension terminating in a 2¼″ heel of standard dimensions. Upon the metal extension is threaded a ring, on the under surface of which is attached and asbestos gasket. The opal envelope is pressed in a mold instead of being blown, this insuring uniform thick-



Photometric Curve of Envelope Unit.

ness and size. There is a simple raised design, not pronounced enough to cause any cleaning difficulty, but relieving the plainness of the unit and giving it an artistic appearance.

In assembling the unit, the opal envelope rests on the flange of the reflector being sealed at that point by a

rubber gasket. The ring on the metal extension screws down upon the top of the envelope, the asbestos gasket making a dust-tight contact. After the unit is once assembled, there is no necessity for separating the parts. The only surfaces needing cleaning are the interior smooth surface of the prismatic reflector and the exterior smooth surface of the opal reflector.

The high degree of light control obtained with this type of unit is graphically shown by the photometric curve. The maximum candle-power is directed at such an angle as to light the window seats in a car to the same intensity as the remainder. By actual test, this unit gives an average illuminating in the car of 3.67 foot candles when using 50-watt lamp on two-seat spacing—52% useful lumens. Excluding mirrored glass reflectors, Holophane prismatic reflectors and Holophane Iris reflectors are the only other two types that approach this high efficiency.

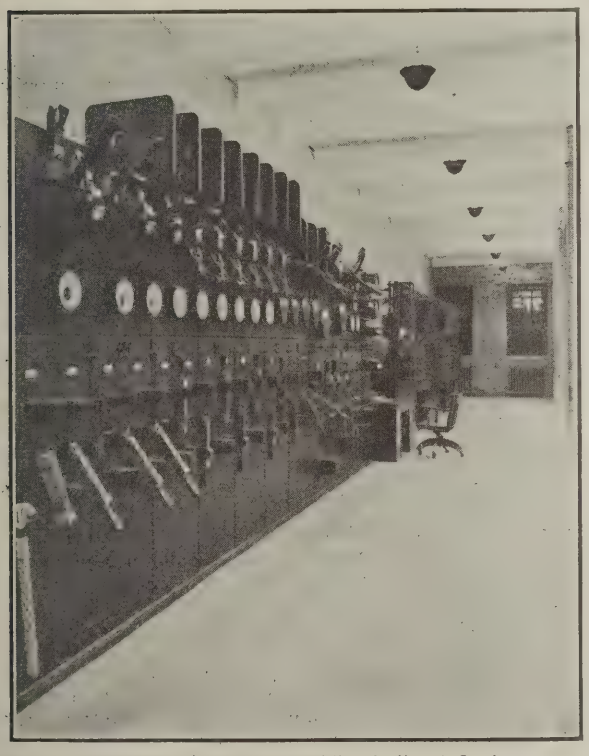
An installation of this unit is being made on a Lake Shore passenger coach and data will soon be available as to its performance under actual service conditions. Unfortunately the installation was not ready in time to obtain photographs.

The reflector-envelope unit is being manufactured by the Holophane Works of G. E. Company, according to their policy of developing special reflectors which will aid in the advancement of methods of car lighting. The unit bears the catalogue number 18322.

Good Lighting for Power Stations and Offices

The power station, the main spring of the plant or shop, must be provided with good illumination. The smooth operation in every department depends upon the reliability of the source of power. The stoppage of any large unit or any delay in making repairs due to poor lighting, will cause an enormous loss in time and money.

A good working intensity of illumination should be provided, and shadows should be eliminated as nearly as possible from all switchboards, gears, bearings, gauges, movable and adjustable parts.



Power Station Illuminated by Indirect System.

It is also of the highest importance that the Station never be left in darkness. Hence in many cases the wise precaution of providing an alternate or emergency lighting system is carried out.

We illustrate in Figure 1 a new Substation of the United Electric Light and Power Company, New York City, which was intended to be a model of up-to-dateness, and the finished plant shows that the designers did not fall short of their purpose. Along with hundreds of other details the lighting of this plant was carefully considered. The main transformer and rotary room, which is shown in the illustration is 26 ft. 6 ins. wide and 89 ft. long, with a high ceiling of 31 ft. All lighting equipment is placed above the crane, which operates lengthwise of the room.

This room is equipped with two entirely independent lighting systems, and the failure of one will not affect the other. They are so arranged that it will be almost impossible for the station to be left in darkness.

The direct lighting system consists of 20 X-RAY Beehive reflectors placed at the ceiling, using 100 watt lamps. This arrangement produces a perfect illumination on the floor and at an energy consumption of .85 watts per square foot.

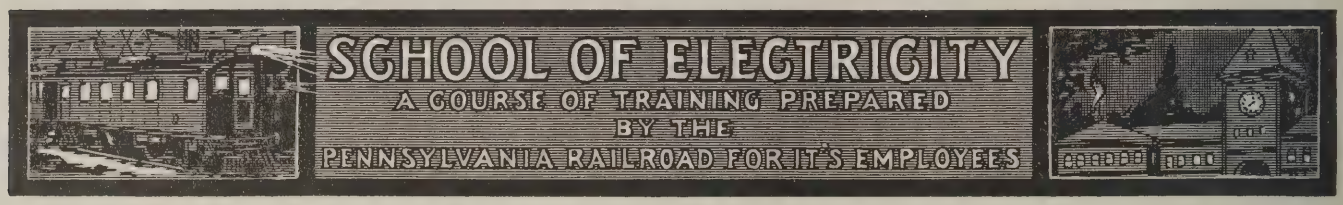
In addition to the Beehive lighting equipment there are five 500 watt EYE COMFORT indirect lighting fixtures which hang 42 ins. from the ceiling. The ceiling is painted a dull white. The indirect lighting system consumes 1.06 watts per square foot.

Indirect Lighting in a Private Office.

The photograph of the transformer room, shown on this page, was made at night without the aid of any flash light. Only the lamps contained in the Beehive reflectors were burning, the indirect lighting fixtures not being lighted.

The fixture bowls may be lowered for cleaning, which is done by a mere wiping with a damp cloth, as soap and water is never used in cleaning the inner surface of X-RAY reflectors, which is fire glazed.

In order to keep the lighting system up to its original standard of efficiency a regular schedule for cleaning and renewals should be used. This should be made a part of the regular routine of those in charge of the building. The design of construction of the reflectors used for both the direct and indirect lighting is such that the matter of cleaning is very much simplified. Lamps need not be removed nor need the reflector be handled. This fact of arranging for the cleaning and renewals in such a way as to obviate the necessity for their being handled, as would be true in case of washing, effects a very material saving in maintenance cost, as reflectors or lamps are hardly ever broken.



Editor's Note:—Through the courtesy of the officials of the Pennsylvania Railroad, we have been given special permission to publish this entire course in the *Railway Electrical Engineer*, so this valuable training in electricity, which was originally intended only for P. R. R. men, now becomes available to all railroad men. A complete lesson of this course will be published in each issue.

Lesson No. 5

Mathematics

The following signs are frequently used in connection with the different computations and formulas, so that their meaning and applications should be made familiar:

+Plus, indicates addition; thus, 8+5 are 13.

—Minus, indicates subtraction; thus, 8—5 are 3.

×Times or multiplied by, indicates multiplication; thus, 8×5 are 40.

÷Divided by, indicates division; thus, 20÷5 are 4.

=Equals or equal to, indicates equality; thus, 4+5=9, or 3 ft. =1 yd.

±Plus or minus, indicates a positive or negative quantity.

∓Minus or plus, indicates a negative or positive quantity.

ab or $a \cdot b = a \times b$, indicates "a" multiplied by "b," and may be written in any of the three ways.

$\frac{a}{b} = a/b = a \div b$, indicates that the quantity "a" is to be divided by the quantity "b."

$.2 = \frac{2}{10}$ $.002 = \frac{2}{1000}$ Decimal fractions.

( ), [ ], , called parenthesis, bracket and brace, respectively, have the same meaning and indicate that the operations within them must be performed first. When two or more are used, the innermost must be effected first; thus, 8 (6—3) shows that the subtraction must be performed first before multiplying by 8. When a minus sign, —, is just before the bracket and it is desired to remove the bracket to simplify the quantity, then the plus and minus signs inside this bracket would be changed as follows:

5 [6—(3—½)] would be written.

5 [6—3+½] or 5×3½ equals 17½.

———, called the vinculum, is used for same purpose as the parentheses, but most frequently with the radical sign √.

$\sqrt{\ }$, called the radical sign, and indicates that the square root of the quantity under it is to be found.

$\sqrt[3]{\ }$, $\sqrt[4]{\ }$ indicates that the cube root and the fourth root, respectively, are to be found.

a^2, a^3, is read "a" squared and "a" cubed, meaning that "a" is to be used twice as a multiple or three times, respectively. It is same as $a \times a$, or $a \times a \times a$. The figures 2 and 3 as used here are called exponents.

$a^{\frac{2}{3}} = \sqrt[3]{a^2}$, $a^{3/2} = \sqrt{a^3}$, fractional exponents, and are read "a" to the $\frac{2}{3}$ power and "a" to the $3/2$ power. The denominator of a fraction used as an exponent shows what root is to be found, and the numerator indicates the number of times the quantity is to be used as a multiple.

: means ratio or divided by; thus 2:4 is read in the ratio of 2 to 4, or $2/4 = \frac{1}{2}$.

: :: : proportion signs; thus, 2:4::8:16, and is read 2 is to 4 as 8 is to 16.

Expressed as an equasion, $2/4 = 8/16$.

∴ means therefore.

>means greater than.

<means less than.

° degrees of a thermometer or an arc.

′ minutes or feet.

″ seconds or inches.

′ ″ ‴ accents to distinguish letters or quantities; as a' a'' a''', and read a prime, a second and a third.

a_1, a_2, a_3, subscripts to distinguish letters or quantities, and read a sub one, a sub two, etc.

a^{-2}, a^{-3}, negative exponents, indicates that the reciprocal of the quantity raised to the given power is to be taken. It is read "a" to the minus 2 power, "a" to the minus 3 power. These quantities are equal to $\frac{1}{a^2}$ and $\frac{1}{a^3}$.

π read pi, and is the ratio of the diameter to the circumference of a circle, and is equal to 3.1416, which is approximately $3\frac{1}{7}$.

It is assumed that the common operations, such as addition, subtraction, multiplication and division, in which whole numbers are involved are thoroughly familiar. In order to refresh the memory a short review of mixed numbers and fractions may not be out of place.

FRACTIONS.

In the fraction ¾ the numerator is 3 and the denominator is 4. The denominator shows the number of parts into which the thing is divided and the numerator the number of parts taken.

Common denominator is a denominator that will contain each of the denominators of several fractions without a remainder. The numerators of each fraction are then multiplied by the number of times its denominator is contained in the common denominator. For example, ½, ¾, ⅞ have a common denominator of 8, and ½ = 4/8; ¾ = 6/8; ⅞ = ⅞.

Reduce a fraction to its lowest terms. Divide both numerator and denominator by the greatest number that each will contain without a remainder; for example, in 12/16 the greatest number that will thus divide both 12 and 16 is 4; so that $\frac{12 \div 4}{16 \div 4} = \frac{3}{4}$, which has the same value as the original fraction 12/16.

Multiplying or dividing both numerator and denominator of any fraction by the same number does not change the value of the fraction.

A mixed number is one consisting of a whole number and a fraction; as, 4⅜.

An improper fraction is one whose numerator is equal to or greater than its denominator; as, 35/8. This may be reduced to a whole or mixed number by dividing the numerator by the denominator, the quotient being the whole number and the remainder the numerator of the fraction having same denominator as the improper fraction; thus, 35 ÷ 8 = 4⅜. A mixed number may be changed to an improper fraction by multiplying the whole number by the denominator of the fraction, adding the numerator and placing this sum over the denominator of the original fraction. For example, $3\frac{1}{2} = \frac{(2 \times 3) + 1}{2}$

Adding Fractions or Mixed Numbers

Fractions alone may be added by reducing them to a common denominator, as mentioned above, then adding the numerators and reducing the sum to a whole or mixed number. Mixed numbers are added by adding separately the whole numbers and the fractions and adding these sums; thus, $3\frac{1}{2} + 4\frac{1}{4} = (3+4) + (\frac{1}{2} + \frac{1}{4}) = 7 + (2/4 + \frac{1}{4}) = 7\frac{3}{4}$.

Subtracting Two Fractions or Mixed Numbers

First reduce the fractions to common denominator and subtract the numerators; thus, $\frac{7}{8}'' - \frac{1}{4}'' = \frac{7}{8} - 2/8 = \frac{5}{8}''$. When mixed numbers are to be subtracted, subtract the whole numbers and fractions separately and place their remainders together; thus, $4\frac{1}{2}'' - 2\frac{1}{4}'' =$

$(4\frac{1}{4}''-2'')+(\frac{1}{2}''-\frac{1}{4}'')=2\frac{1}{4}''$, or if the minuend, or larger number, has the smaller fraction, as follows: $5\frac{1}{2}''-2\frac{3}{4}''=(4''+{}^2/_2''+\frac{1}{2}'')-2\frac{3}{4}''=(4''+{}^4/_4''+{}^2/_4'')-2\frac{3}{4}''=2\frac{3}{4}''$.

Multiply Fractions.

The numerators should be multiplied together, also the denominators, and then divide the numerator by the denominator; thus,

$$\frac{3}{8}\times\frac{7}{12}\times\frac{1}{2}=\frac{3\times7\times1}{8\times12\times2}=\frac{21}{192}=\frac{7}{64}$$

Divide Fractions.

When multiplying mixed numbers change them to improper fractions and proceed as above.

First Lesson.

1.—Reduce to a common denominator the fractions ${}^3/_{15}$, ${}^3/_{10}$, $\frac{1}{2}$.
2.—Reduce to lowest terms the following fractions: (*a*) ${}^9/_{12}$, (*b*) ${}^{10}/_{15}$, (*c*) ${}^4/_{20}$, (*d*) ${}^6/_{10}$.
3.—Change to mixed numbers the fractions (*a*) ${}^{40}/_{70}$, (*b*) ${}^{35}/_{10}$, (*c*) ${}^{15}/_8$, (*d*) ${}^{20}/_3$.
4.—Change to improper fractions the mixed numbers (*a*) $3\frac{1}{2}$, (*b*) $5\frac{2}{3}$, (*c*) $7\frac{8}{18}$, (*d*) $2\frac{7}{12}$, (*e*) $4\frac{1}{2}$.
5.—Add the fractions (*a*) ${}^7/_{18}$, ${}^3/_{10}$, $\frac{1}{2}$; (*b*) ${}^5/_{12}$, $3\frac{1}{3}$, $\frac{5}{8}$.
6.—Subtract the following: (*a*) ${}^8/_{10}-{}^3/_5$; (*b*) ${}^3/_5-{}^3/_{10}$; (*c*) $\frac{1}{2}-\frac{1}{3}$; (*d*) $3\frac{1}{2}-2\frac{1}{3}$; (*e*) $3\frac{1}{2}-1\frac{3}{4}$.
7.—Multiply (*a*) ${}^3/_5\times\frac{1}{4}\times{}^7/_{10}$; (*b*) $\frac{1}{2}\times\frac{1}{3}\times{}^9/_{11}$; (*c*) ${}^1/_5\times{}^{13}/_7\times{}^{11}/_{20}$.
8.—Divide (*a*) $\frac{1}{4}\div\frac{1}{2}$; (*b*) $3\div{}^1/_7$; (*c*) $14\frac{1}{2}\div{}^9/_{11}$; (*d*) ${}^4/_{13}\div4\frac{1}{3}$.

(To be Continued)

LESSON 21

SAFETY TYPE "F" EQUIPMENT.

The Safety type F dynamo regulator is of the combination current and voltage type, that is, it operates as a simple constant current regulator until the battery voltage rises to 40 volts near the end of the charge. It controls thereafter as a constant voltage regulator, and as the battery counter electro-motive force rises as the charge is continued, the battery charging current will taper down to a low value. The principle underlying the operation of this type of regulator was described in our June lesson No. 17 in connection with the Gould Simplex System and if this fundamental principle is not well understood, it will be well to refer to that lesson.

Safety Suspension.

The new Safety suspension is of the drop form design, and presents many novel features not obtained by other types of suspension. A side elevation of the suspension is shown in Fig. 120.

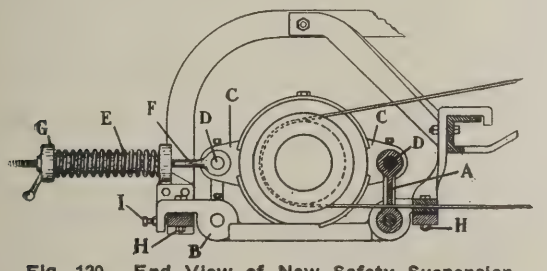


Fig. 120. End View of New Safety Suspension.

The dynamo is supplied with four lugs C which are cast as an integral part of the magnet frame. These lugs are drilled for the supporting shafts D which pass through the lugs and through the solid links A, the links being as long as the distance between the lugs. The lower end of the link A is supported by a shaft which passes through the link, and through the supporting frame B. The shafts D are locked in the lugs of the generator and in the supporting frame, so that the turning motion is wholly on the shaft D and links A, and no wear can occur on the generator lugs or supporting frame. This arrangement gives a parallel suspension with the points of support below the generator.

The tension spring bracket is bolted to the supporting frame, and the tension rod F is secured to the end of the shaft D, the pull of the tension spring E tending to pull the generator in a direction away from the truck. The tension rod F is threaded so that the tension nut G cannot be screwed beyond a predetermined position on the rod F. When the links are in a vertical position the belt tension is due only to the pull of the spring E. If the belt is of such a length that the links are inclined away from the truck, a part of the weight of the generator is added to the belt tension. This amount depends upon the distance the generator is off the vertical. In moving this distance the tension spring has released somewhat and will give less pull. The spring is so designed that the loss of tension in the spring is equal to the additional tension due to the generator weight, and the total tension on the belt remains constant. If the links are inclined toward the truck the weight of the generator is subtracted from the increased spring tension, and the belt tension is constant.

This feature of constant belt tension, and having a limit to the amount of tension a man can apply, is very important, as it does away with the excessive belt strains, which are sometimes considered necessary to prevent the belt slipping when the tension has decreased, due to the belt stretching. This suspension as designed, gives a constant tension with a stretch of at least six inches.

So far, however, we have considered only the dead weight of the generator coming on either the belt or spring, depending whether the links are inclined away from the truck or toward it. When the train is traveling at high speed and the generator is bounding up and down with the truck in motion, the dynamic stresses set up will greatly alter the perfect balance between the generator weight and the pull of the spring. Under these conditions the generator may deliver a blow on the spring or belt of many times its own weight and for this reason it is always desirable to keep the generator links as nearly vertical as possible This same principle applies to the under-hung suspension and old rocker type suspension.

All parts of the suspension which are subjected to wear are lubricated; grease pockets with felt retaining washers, being provided for all such parts.

The arrangement for lining up the generator with the car axle is simple and easily operated. The supporting frame B is secured to the suspension irons by six bolts H. The center bolt on the front side passes through a round hole in the supporting frame and suspension irons. The holes in the supporting frame for the other five bolts are slotted so that the whole frame B can be swung around the center bolt. To line up the generator it is only necessary to loosen all the bolts, line up the generator by means of the adjusting bolts I, and lock it securely in position by means of the six bolts H.

On account of the absence of long supporting bars

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Safety, Comfort, Economy

These three essentials make for passenger service. The Alexalite embodies safety in illumination because all parts are metal.

There is solid comfort from the Alexalite system of illumination because all light points are concealed from the range of vision and the illumination approximates daylight.

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The Maxolite Gives 55% More Light, Saves 20% in Power

The Maxolite is an ideal direct lighting fixture for railroad yard, factory, machine shop, etc. It is a ***one piece*** porcelain enamel steel reflector with high illuminating efficiency. There is nothing to wear out.

In one factory twelve Maxolites equipped with Mazda lamps, replacing arc lamps, showed a saving of nearly $450 in less than five months, giving 55 per cent more light.

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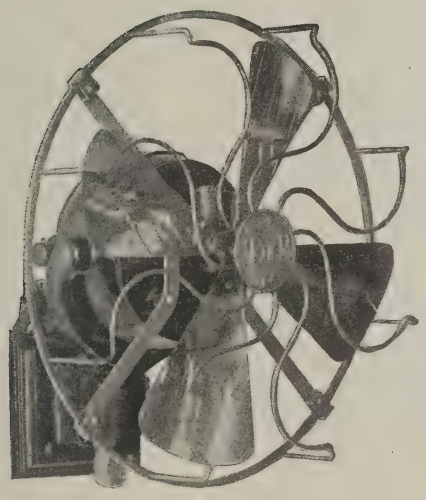

Diehl Car Fans

give a finishing touch to passenger comfort. Just the turn of a switch in a closet by the porter starts the fan. It is silent and unobstructive. The fan body is readily removed from the base without disturbing the wiring. The general design of both base and fan body is pleasing. Diehl car fans make for greater comfort.

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save you 65 per cent in fuse cost. This saving is due to the fact that they may be refilled at low cost. Some of their advantages are: full rating on label; safe indicator; no metal exposed; extra heavy caps and tubing; ampere capacity stamped in fiber and perfect alinement of soldered blades.

centrically around the conductor. The result is a product absolutely dependable. The wiring installed in railway cars should be the best. Okonite is made in one grade only—the best.

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the space around the generator is clear, allowing ample room for inspection of the generator, and the removal of pulley, armature, or heads when this is necessary.

As all working parts of the suspension are assembled complete with the generator before shipment, the proper operation of the suspension is not dependent on the assembling of the suspension on the truck by the car builders. The supporting frame is supported by the type of suspension irons suitable to the truck used. In the illustration one side is supported by a cross member fastened to side irons extending from the truck ends, while the other side is held by a bracket bolted directly to the end sill. This arrangement is very good, half of the weight of the generator is supported directly from the truck instead of the whole weight coming directly on the side irons.

Safety Type F. Regulators.

The Safety Type F Dynamo Regulator is designed to protect the dynamo from overload, and the batteries from

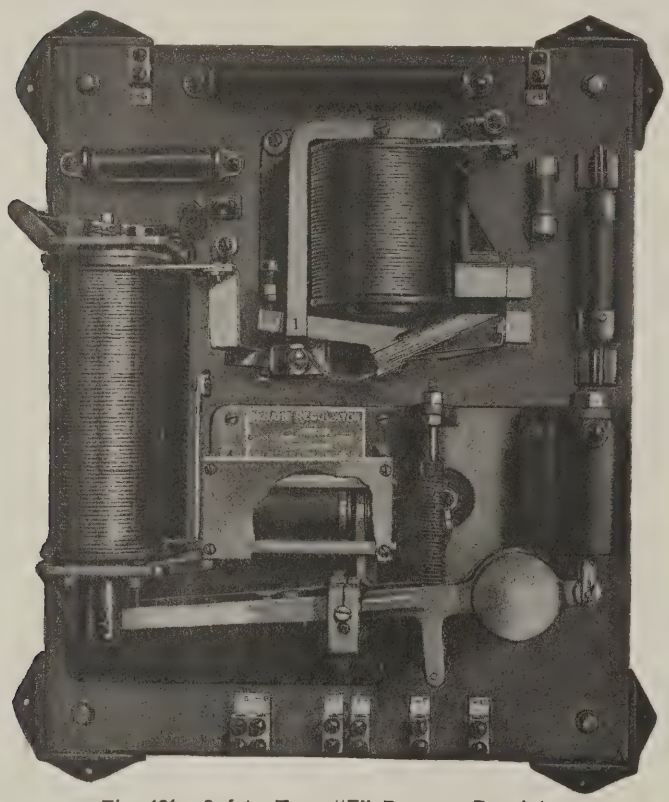

Fig. 121. Safety Type "F" Dynamo Regulator.

over-charge, and to provide re-charging of the batteries in the shortest possible time, when re-charging is necessary.

A view of the dynamo regulator is shown in Fig. 121 and the wiring diagram in Fig. 122.

The dynamo is controlled to give the proper output through changes in speed and battery condition, by the amount of current supplied to the shunt field. This field current is controlled by the resistance of the carbon pile C, Fig. 122, in series with the field. The resistance of this carbon pile is determined by the pressure exerted on it by levers operated by the plungers of magnets A and S. The windings of S carry the total current output of the dynamo; the windings of A carry dynamo voltage, and the pull of this magnet is proportional to the dynamo voltage. If the current output tends to rise above that for which the regulator is set the plunger of the coil S, through its lever, reduces the pressure on the carbon pile C, reducing the field current and holding the current output to its proper value. If the voltage tends to rise above that for which the regulator is set the plunger of the coil A, through its lever reduces the pressure on the carbon pile C, and holds the voltage to its proper value.

The coil S is set to hold the current value to the full output of the generator. The voltage coil A is set for a maximum voltage of 2.5 volts per cell of battery, or 40 volts with a 16 cell equipment of lead batteries. With this as a maximum voltage, overcharging of the batteries will not be at all serious, as the current to the

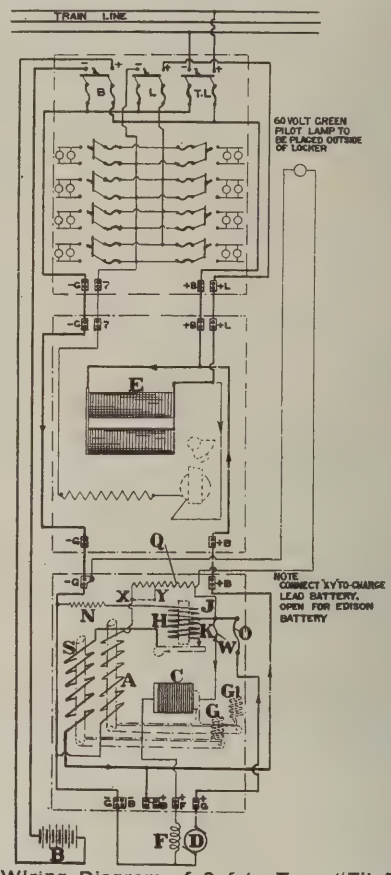

Fig. 122. Wiring Diagram of Safety Type "F" Regulator.

batteries will automatically taper down to a low value as the batteries become fully charged.

As the output of the dynamo is limited to its full output by the series coil S, the dynamo cannot be overloaded, either by lamp load, or charging an exhausted battery. At the same time the full output of the dynamo is available for battery or lamp load whenever it is needed. An equipment with this system of regulation with a generator of a given size will maintain the service with a higher lighting load than with a system in which the regulator maintains the battery current constant, regardless of lamp load.

The auto-switch is of the closed magnetic circuit type with pivoted armature. It has a dynamo shunt lifting coil which when the dynamo voltage equals the battery voltage, lifts the armature, bringing into action the series coil, which holds the switch tightly closed, and assists in opening the switch when the dynamo voltage falls below battery voltage. Carbon contacts are provided to prevent arcing at the main brush.

All parts of the dynamo regulator are mechanically balanced, and the regulation accomplished by springs. This gives constant and close regulation, in spite of the jars incident to railway service. On account of this balancing heavy liquid dashpots are not necessary, and inverted air dashpots with graphite plungers are used.

These are constant in action winter and summer, regardless of climatic or temperature changes, and do not become clogged with the dust of service.

Lamp Regulator.

The lamp regulator, Fig. 123, consists of two piles of carbon discs in series with the lamps, the two piles being in parallel. The pressure on these carbons, and therefore their resistance is determined by the armature of a magnet, the windings of which receive lamp voltage.

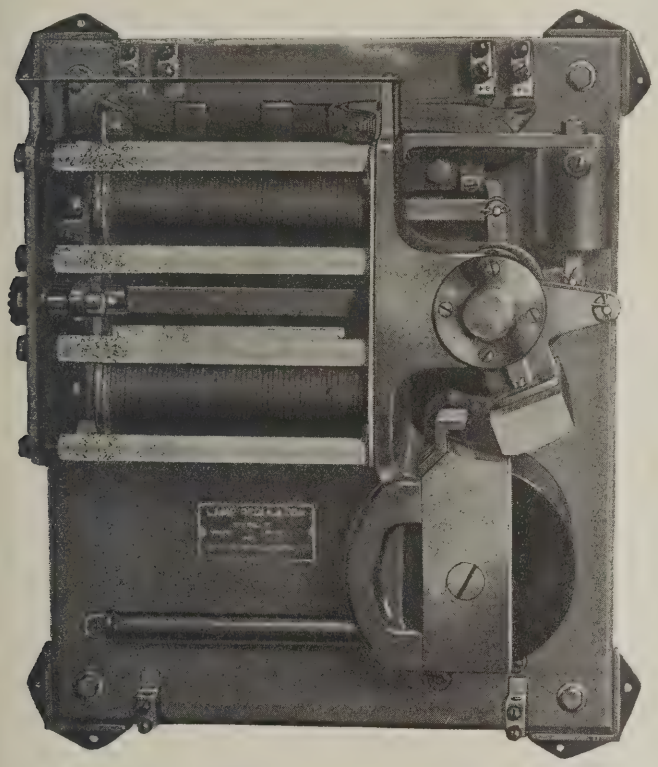

Fig. 123. Safety Type "F" Lamp Regulator.

By a unique design of magnet and levers a high degree of accuracy in voltage regulation is accomplished without the use of any auxiliary control.

An air dashpot of the same type as used on the dynamo regulator is employed on the lamp regulator.

All co-operating parts of the dynamo and lamp regulators are built up as units on metal frames. These frames are secured to the slate panels, but the operation of the parts is indepedent of the mounting on the slate panels.

Any parts may be removed without disturbing the slate panel, and all connections are accessible from the front.

Voltage coils on both dynamo and lamp regulators are compensated for change in voltage due to heating of the coil windings by zero heat co-efficient resistance placed in series with the coils.

Editor's Note:—On account of the large amount of space taken up by the Convention Reports in this issue we must omit the Practical Stunts Column and Question Box. They will be resumed as usual next month. All car lighting men should read the reports on pages 145 and 156.

DISTILLED WATER FOR BATTERIES.

The use of pure distilled water in connection with your car lighting batteries is a subject of the greatest importance to railway electrical engineers.

Many batteries die prematurely. Their life is shortened by the use of impure water. Iron, chlorine and nitrates all increase local action and the rapid deterioration of the elements. Distilled water eliminates the ills due to impurities in ordinary water, and this means a greatly increased life and much greater efficiency.

It is common practice on some railroads to use condensation water from steam pipes, engines, etc., for this purpose. This is extremely bad practice, as condensation water often contains oil, boiler compounds and other impurities. In an ordinary boiler the water is vaporized at a much higher temperature than the normal boiling point of water, so many of these impurities which are not volatile at 212 degrees are carried over with the steam.

Realizing this situation, the merits of the Rochlitz Automatic Water Still are at once evident. This Still delivers aerated and absolutely pure water direct from the apparatus. Its operation is exceptionally economical, both as to fuel and water. There are no parts to corrode, as it is constructed entirely of copper and brass and heavily lined with pure block tin.

This Still is handled by William M. Lalor, Manhattan Bldg., Chicago, and will be shown at the convention of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Indirect Lighting in Diners

The new system of indirect lighting employed on the new Burlington diners, as described in another part of this issue, seems to be a big step forward in the progress of railway car lighting. A car beautifully lighted with no lighting fixtures to be seen seems almost a paradox and to some might seem absurd from the artistic point of view, yet the cheerful and roomy effect of the brightly illuminated upper deck, entirely free from the forest of fixtures found in some cars, more than compensates for the lack of decorative effect produced by ordinary car fixtures.

The first impression upon entering this car is that it is brilliantly lighted. This undoubtedly is due to the fact that the eye is immediately drawn to the upper deck which is brilliantly illuminated and soft even illumination results which is entirely free from perceptible shadow and very restful to the eye.

As in any indirect system, the service efficiency depends very largely upon the care with which the reflecting surface and lighting units are kept clean. It would seem that this is a marked improvement in railway car lighting, but in order to have it really successful this point will have to be given due consideration.

The Interior Finish of Cars.

To even the casual observer, there has been in the past few years, a marked change in the design of interior finish of passenger cars. The day of the elaborately carved mahogany panel is past and apparently with it has gone the old bronze husk type fixture, much to the satisfaction of those who understand what constitutes a proper system of illumination.

The modern car seems to be designed far more from the utilitarian point of view than the better class cars of a few years ago, although with the practical application of some of the fundamental principles of illumination, the lack of expensive decoration is more than compensated for by the bright and cheery appearance of the cars produced by properly designed lighting fixtures and lighter color tone in the decorative scheme of the car.

The committee on illumination in its report at the recent convention made as one of its most important recommendations, that the head linings of cars be made of a comparatively light color. Although the tests for efficiency and distribution showed that the color of the head lining made practically no difference in the amount of light delivered to the reading plane, the committee stated that in so far as the effect on the eye and the general artistic appearance of the car was concerned, the light colored head lining is much to be preferred. In any system of illumination it was always desirable to avoid a sharp contrast between the brightness of the lighting units and the background. If the lighting units are viewed against a dark background, such as would be produced by mahogany panels, this contrast forms one of the chief causes of eye strain. With a light color head lining, however, the contrast between the lighting unit and its background will not be so marked and the eye strain will be greatly reduced.

The Railroad Electrician's Club.

It has been decided to reorganize the car lighting club on a slightly different basis than in former years. The dinner feature will be entirely eliminated and meetings will be held in a meeting room of the General Managers' Association on the 18th floor of the Transportation Building, Harrison and Dearborn Sts., Chicago.

Instead of having a speaker talk on a certain subject, which is sometimes over the heads of most of the boys, the club will be conducted this year on more practical lines in which the men themselves take part, and the educational feature will be strongly emphasized. In order that such an educational scheme be successful, there must be some foundation to work from, so it has been decided to take up in the meeting the lessons of the Pennsylvania "School of Electricity" as published during the past few months in the *Railway Electrical Engineer,* and study them lesson by lesson, working out the problems and answering any questions that may come up. There will also be a "Big Question Box" for any questions which the boys may care to submit.

With all the engineering talent among the prominent railroad men and supply men who will attend these meetings, we ought to be able to handle most any question that arises.

It is through the courtesy of the General Managers'

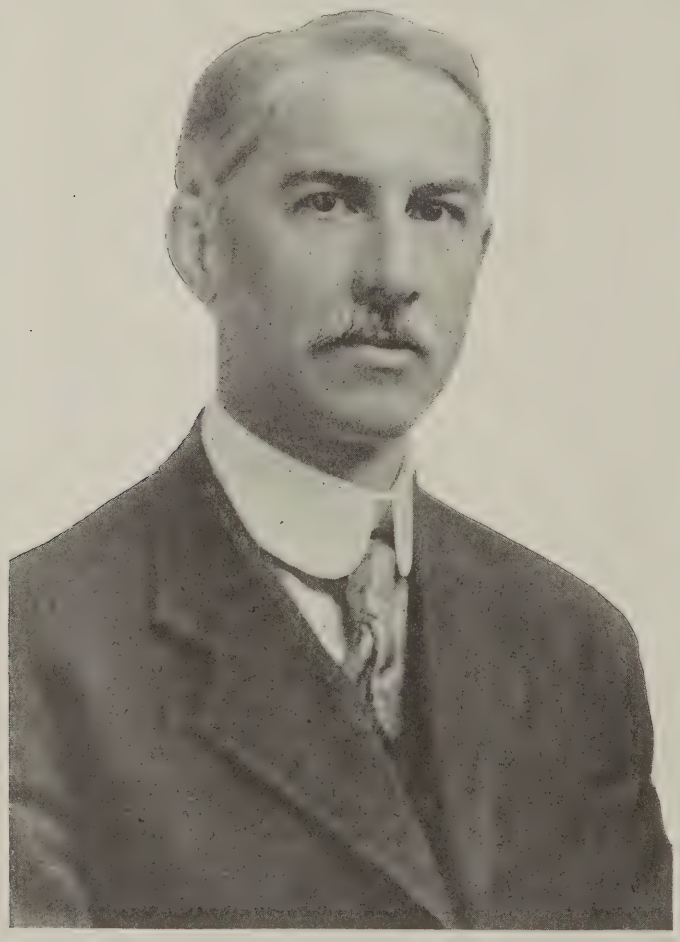
Association, who offer this room to the club gratis, that the club is able to run, for the present at least, without dues or funds of any kind.

For those who wish to take dinner down town a reservation will be made at the Grand Pacific Hotel for dinner at 6 P. M., after which the party will adjourn to the Transportation Building.

Our New Presidents

At the close of the recent A. R. E. E. convention in Chicago last month, Mr. C. R. Gilman was elected president for the coming year of the Association of Railway Electrical Engineers, and Mr. C. W. Bender, president of the Railway Electrical Supply Mfgrs. Association. Both of these men are old pioneers in railroad work and both are counted among the organizers of the Association.

Mr. Gilman began his railroad career as an apprentice in the Baldwin Locomotive Works in June, 1876. In July, 1882, he severed his connection with that company and went to work in the locomotive department of



C. R. Gilman, President A. R. E. E.

the Pennsylvania Railroad at Altoona, as machinist.

About this time he became acquainted with Mr. Geo. Gibbs, the mechanical engineer of the C., M. & St. P. R. R., who was at that time experimenting in car lighting by electricity. Upon receiving an offer of a position with Mr. Gibbs, Mr. Gilman severed his connection with the Pennsylvania Railroad and became Mr. Gibbs' assistant.

During the next few years he became actively interested in the development of car lighting and the application of other electrical machinery to railroad operation. In 1893 Mr. Gilman was appointed chief electrician in charge of the electrical department, including power plants, stations, and train lighting, which position he still holds.

Mr. C. W. Bender has been in the railroad work since 1889, when he entered the employ of the Pennsylvania Railroad as an electrical helper. In this department he advanced rapidly and in 1903 was made assistant to

C. W. Bender, President R. E. S. M. A.

Mr. J. R. Sloan, then electrician motive power department of the Pennsylvania. In 1909 he resigned from the Pennsylvania to accept the position of commercial engineer with the National Electric Lamp Association. Since that time, although employed by a manufacturing concern, Mr. Bender has kept up his railroad activities and interests to a remarkable extent. Among other things, he has written two hand books on railway car lighting, which are extremely valuable to the men in this particular field.

With the two associations headed by men of this calibre there cannot be much doubt about the effectiveness of the association work for the coming year.

ASSOCIATION NEWS.

At the recent convention of the Association the annual dues were raised to the following schedule;

Honorary, none; Senior active, $4; Junior active, $3; Associate, $3.

Secretary Andreucetti advises that he has obtained a new line of Association buttons for the active members, which are slightly different from the former buttons in that the letters A. R. E. E. are in white enamel with a maroon background.

The Association is now in better condition in every way than at any time in its history. From the line up of the new committees, as given on page 24 of this issue, it looks as if we are going to have a working organization throughout the year which should give us some strong committee reports for 1914.

The Association needs the active personal support of everybody in getting new members. Let's each of us who counts himself a live wire plan on getting one new member before the first of the year.

Report of the Sixth Annual Convention of the Association of Railway Electrical Engineers

TUESDAY MORNING SESSION.

Meeting was opened with a brief address of welcome by President Cartwright, Electrical Engineer for Lehigh Valley Railroad, after which the Secretary, Andreucetti, presented his report as to finances and membership, as follows:—

The proposed amendments to the constitution, which are in substance as follows:

(1.) Extending the Senior Active membership of the Association to include, "Any person directly, or indirectly in charge of electrical equipment on any railroad, on recommendation of his superior, who must be a Senior Active member, is eligible to membership as a Senior Active member of this Association."

(2.) "Any person engaged in Consulting Electrical Engineering work and not engaged in the manufacture or sale of electrical appliances, is eligible to Active membership upon recommendation of three Senior Active members. He, however, will not be eligible to vote on recommendations for standards or standard practice."

(3.) "Any person who is engaged in electrical work on any railroad on recommendation of his superior and a Senior Active member, (provided his superior is not) is eligible to membership in this Association as a Junior Active member. Any person who has at any previous time been engaged for a year or more in railway electrical work, but who is at present engaged in other lines, is eligible to Associate membership. If he again engages in active railway electrical work, he may at once become a Junior active member upon approval of the Executive Committee."

(4.) "The annual dues of this Association are as follows:

Honorary, none; Senior Active, $4; Junior Active, $3; Associate, $3."

(5.) "On any question pertaining entirely to electric car lighting the ranking senior active member of any road will vote the electrically lighted cars owned by the road which he represents as follows: One vote per car."

(6.) "On any questions pertaining to standards, standard practice or specifications, etc., other than electric car lighting exclusively the Ranking Senior Active member of any railroad shall be entitled to one vote on each question."

(7.) "Proposed amendments to the constitution must be offered in writing, signed by not less than five *Active* members, and must be published in the advance notice of the Annual or *Semi-Annual* meeting. The amendments shall be acted upon at such Annual or Semi-Annual meeting and shall be adopted if the votes of two-thirds of the Senior Active members voting are affirmative."

Committee on Standard Reports for Operation.

The report as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. F. E. Hutchison, (formerly Rock Island), Chairman. In discussing the report, Mr. L. S. Billau, (B. & O. R. R.), pointed out the importance of keeping an accurate record of failures, but said that where a large number of cars were handled at any one terminal the matter might become rather cumbersome unless a satisfactory system was worked out. Mr. Hutchison described a system of reporting employed by them, in which, daily performance reports for each car were sent in and these were then copied on a card form. This system was satisfactory when they had but 150 cars to take care of, but it was found to be rather cumbersome when this number was increased to over 300. They now employ a loose-leaf system, in which the original daily reports for each car all are filed together, and various colored stickers are pasted on the reports, the color of which indicate failure, belt trouble, battery washings, etc.

President Cartwright described the system employed by the Lehigh Valley, in which three different colored reports were employed; the trouble slip is printed on pink paper, the storage battery report on yellow, and the electrical inspector's report, on white. Two carbons for each report were made out, one sent to the electrical engineer, one retained by the inspector, and the original sent to the mechanical department. In this way the electrical engineer knows at all times the condition of his equipment and what inspector reported any particular case of trouble. All the slips for each car are filed together.

As to keeping a record of cost of operation, Mr. Cartwright stated that the electrical inspector's report contained a column indicating the cost of equipment and although this might vary from time to time, the total cost of maintenance as taken from this report, should be within a few per cent of the correct value.

Secretary Andreucetti stated that the report of this committee, as published in the 1911 proceedings of the Association, contains a very complete and practical method of cost accounting. (*A pad of these car lighting cost blanks will be gladly furnished to any Senior Active member upon the request to the Railway Electrical Engineer.*)

TUESDAY AFTERNOON SESSION.

Committee on Head-end Equipment.

Secretary Andreucetti then read the report of the committee, as publised in the October issue of the *Railway Electrical Engineer.* The report contains a very complete description and comparison of certain features of the various head-end systems now in use. It is an unusually instructive report and will be of great value to all interested in the operation of head-end equipment. The report was accepted and referred to the committee on standards for their consideration and recommendation of a standard system of head-end lighting.

Committee on Terminal Facilities for Handling Car Lighting Equipment.

The report of this committee, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. Geo. B. Colgrove, (I. C. R. R.). Mr. E. S. MacNab, (C. P. R.) in discussing this report asked if it was the general practice to overhaul car lighting batteries at the main shops of the Company, or at the terminal coach yards? He stated that there were over 300 cars electrically lighted on the C. P. R. and at the present time the batteries are overhauled once a year when the cars are shopped. He said that he considered it now advisable to transfer the periodical cleaning of the storage batteries from the shops to the terminal coach yards. Mr. Colgrove, (I. C. R. R.), pointed out the fact that it is not always satisfactory to clean the batteries when the cars are shopped, due to the uncertain times at which the cars are sent to the shop. A battery might require cleaning months before the time for that car to go to the shop, and on the other hand, the battery might be in excellent condition and not really need cleaning when the car is

shopped. He said that particularly when new coach yards are being laid out arrangements should be made to do all of the battery work at the terminal. He stated that within a few years the Chicago Terminal of the I. C. R. R. would be provided with an entirely new terminal coach yard on new made land south of the present 12th street station. These yards would be laid out with special reference to caring for car lighting equipment.

Secretary Andreucetti, (C. & N. W. R. R.), stated that they remove batteries before the car is sent to the shop and all battery work is done at the battery plant at the terminal coach yards. Mr. Billau, (B. &. O. R. R.), stated that they do all battery cleaning and repair work at one terminal, but said that it is a question as to how many battery plants would be required on a large system employing a great number of car lighting equipments. He said that although the shop idea of cleaning batteries had many objections, it might work out as a very satisfactory method on large systems employing a large number of cars. But in any event, the terminal battery plant should be maintained in order to give the proper attention to the batteries when needed.

Mr. D. Pastorius, (P. R. R.), said that it was the practice of the Pennsylvania Lines, East, to clean all the car lighting batteries at Sunnyside Yards, New York. He said that they tried to shop their cars regularly once a year, but that they very often found that a battery which had been cleaned only a few weeks or months will develop some serious defect, which will require that it be dsimantled and cleaned again. He said that when the cars are shopped the batteries are removed and carefully inspected and all minor repairs made. If it is necessary to clean the batteries, however, they are loaded on the shop car and shipped to the Sunnyside Coach Yards, where there are proper facilities for cleaning. He stated that this method is much cheaper and more satisfactory than trying to maintain a battery shop at each small terminal and at each repair shop. They maintain an eighteen months schedule for cleaning after the first cleaning and there are few batteries that fail before their schedule time for being cleaned.

Mr. A. McGary, (N. Y. C.), stated that they have over 800 car lighting equipments in service and that cleaning is done at Mott Haven Yard. There are a great number of cars, however, that do not reach that point, so it becomes necessary to install cleaning plants at other points. Therefore, it has been decided to establish a battery repair shop in the main shops at Albany, and here all batteries are cleaned as they pass through the shops every year. He stated that some trouble has been experienced in getting the cars at regular intervals, but that the time between shopping is not long enough to cause serious trouble. He said that it was their intention to transfer all battery work to the shops and by spring will have most of the battery cleaning transferred from the Mott Haven coach yards to Albany shops. Mr. H. C. Meloy, (L. S. & M. S.), stated that they made a practice of cleaning batteries at the terminal yard. Upon motion the report of the committee was accepted.

Locomotive Head Lights.

The report of this committee, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. C. R. Sugg, Chairman. Mr. Sugg stated that there has recently been a special committee appointed on this subject by the Master Mechanics Association, composed principally of superintendents of motive power, to investigate this subject, therefore, the committee deemed it inadvisable to express any definite opinion at the present time.

Secretary Andreucetti, then announced the sudden death of Mr. William Beardsley, former General Electrician of the Grand Rapids & Indiana R. R. and moved that a set of resolutions of condolence be prepared and sent to Mrs. Beardsley and that a copy of same be spread upon the records of this Association.

WEDNESDAY MORNING SESSION.

Methods of Charging Storage Batteries.

Mr. J. R. Sloan, Chairman, read the report of this committee, as published in the October issue of the *Railway Electrical Engineer.* This report is a most valuable and instructive one and describes six different methods for charging batteries in the straight storage system. Four different methods in head-end service, and eight methods in axle lighting service with diagrams showing the detail wiring connections in most cases. One of the schemes worked out by the committee for axle lighting is a radical departure from all past practice in that it employs an ampere hour meter to control the operation of the equipment, causing the battery to either float or charge at low current when the battery has been brought up to full capacity in ampere hours. The recommendations of the committee are as follows:

Straight Storage—Constant potential charging source with ballast resistance of fixed value in each outlet and an ampere hour meter with shunt trip circuit breaker on each car.

Head-end System—Charging at constant potential on the train lines with ballast resistance of fixed value and ampere hour meter with shunt trip circuit breaker on each car.

Axle Generator—Constant battery current regulator with voltage limiting control. Ampere hour meter on each car to indicate the charge condition of the battery and show whether terminal charging is necessary.

The committee referred to the new system employing an ampere hour meter for controlling the operation of axle equipments and thought it would give satisfactory operation. In discussing the report, Mr. Billau, (B. & O. R. R.), asked how the ballast resistance method as recommended by the committee for straight storage would actually work out in practice with a battery completely discharged. Mr. Sloan referring to the two charging curves shown on page 161 of the October issue of the *Railway Electrical Engineer,* showing the rate of charge for both the Edison and the lead battery, these both being charged from a constant potential of 93 volts, there being .222 ohms in the lead battery circuit, and .044 ohms in the Edison. In each case these batteries were completely discharged and represented the worst possible condition which would be experienced in actual service. The current with the lead cell varies from 95 amperes to 40 amperes, and the Edison from 160 to 45 amperes.

Mr. Keirns, (P. R. R.), who had charge of this system at Philadelphia, and Mr. Newman, (P. R. R.), who is in charge of the same system at Pittsburgh, stated that with this system it was unnecessary for the station attendant to pay any attention to rheostat, switches, etc. Current is always available at all of the plugs in the yard and it is only necessary for the inspector to plug in a car or remove it at will. The layout of the feeders in the yard is such as to take care of practically all of the charging lines.

President Cartwright then referred to the series versus multiple system of wiring a yard for battery charging. With the series system it is possible to place one, two, or three cars in series and charge them through one resistance. He thought it was an open question as to which system was to be preferred.

Mr. J. R. Sloan, (P. R. R.), said that in certain cases where cars were operated as a block train, all receiving

practically the same amount of discharge, the series method of charging might work out satisfactorily, but in a majority of cases where batteries are received in various conditions of charge, individual treatment of each battery was absolutely necessary in order to prevent serious overcharging. He described one yard in which an individual circuit ran from the switch board to each outlet in the yard and the switch board is arranged so as to place any two outlets in series.

Mr. Keirns, (P. R. R.), pointed out that although the multiple system would be more expensive to install, it would be decidedly less expensive to operate, and would undoubtedly give much better life in that each battery would be given the proper charge.

As to relative cost of installation of the series and multiple systems, Mr. Newman, (P. R. R.), pointed out that while the series system would be somewhat cheaper as to cost of wire, it would require a more expensive and complicated switchboard and generating plant. He advised that in laying out a yard a study be made of the conditions of operation, determining the maximum number of cars charged in any one hour, then allowing for a reasonable increase in equipment the feeder system could be laid out to take care of that maximum condition. He said that their experience showed that the actual number of cars charged was only 35 to 50% of the maximum.

Mr. Keirns, (P. R. R.), said that at the new Philadelphia Yard, which is 1,200 feet in length, there are 182 receptacles. A bus line of 160,000 circular mills feeds one end of the yard, and an 800,000 circular mill feeder supplies the other end; this, after 160 feet of return, tapers to 600,000 circular mills. Laterals are then tapped off these two main bus lines, crossing the yard to supply the plugs on the various tracks. He said that they did not have more than a three volt resistance drop, with all charging plugs in use. The actual amount of copper employed in this system was much less than where individual lines were run to the power station. He stated that the cost of wiring this complete installation was a little less than $100,000.00.

Mr. E. S. MacNab, (C. P. R.), considered that the series method was to be preferred on account of the greater economy in the wiring installation.

Mr. J. H. Davis, (B. & O. R. R.), said that he considered the series method of charging storage batteries as being inherently wrong, and the only excuse for considering that method at all is to save copper. He thought the Association should go on record as being opposed to any series system of charging storage batteries used in car lighting work unless those batteries are so operated as to be in a like condition of discharge. He said that the multiple system of charging seemed to be the only correct one, but that more information would be required than was presented in the committee report in order that such a system might be properly designed. He requested that the committee give some detail information as to the method of designing such a system.

Mr. F. S. Gassoway, (Willard Storage Battery Co.), said that although every one agreed that it was undesirable to charge batteries in series, in certain cases, such as the long yard at Washington, referred to by Mr. Davis, the series system might be justified in that it would at least provide means of giving the batteries a much needed boost, though possibly not bring them up to full capacity. The report of the committee was then accepted with the understanding that an appendix, supplying detailed information as to method of laying out a multiple yard charging system should be made by the committee.

Committee on Standards.

The report of the committee, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. E. W. Jansen, (I. C. R. R.), Chairman. In the general discussion which followed, Mr. C. R. Gilman, (C. M. & St. P. R. R.), asked why placing angle irons under the battery box was disapproved by the M. C. B. committee. Mr. Jansen, (I. C. R. R.), said he considered it good practice to use angle irons for supporting the battery box for he said that the wood in the battery box is eaten entirely away in two years. The angle bars should be so placed that even though the wood eats entirely away the batteries would be supported by the angle bars.

Mr. J. H. Davis, (B. & O. R. R.), said that as a member of the M. C. B. committee, he thought it advisable to reconsider this subject and change the recommendations of the committee to provide suitable angle bars. Mr. Davis suggested that a committee be appointed to standardize armature pulleys. Motion carried to this effect.

There was some discussion in regard to the adoption of recommendation No. 1 to No. 12, made by the committee, particularly in regard to the dimensions of axle pulleys. Mr. Billau, (B. & O. R. R.), stated that very many of the fish belly girder steel cars did not provide sufficient clearance for the 21 in. axle pulley. He thought there should be a 20 inch pulley provided, as this would give sufficient clearance and would still provide proper pulley ratios without requiring a smaller armature pulley.

Mr. Jansen, (I. C. R. R.), said that their experience was somewhat similar to that of Mr. Billau, and they found it was necessary to turn down the inside flange of the pulley about ½ in. This, however, gave sufficient clearance and has apparently never caused belt trouble.

The general opinion seemed to be that we should adhere to the original standards of 17 in. and 21 in. It was then voted to submit recommendations No. 1 and No. 12 to letter ballot.

In referring to the lamp specifications, Mr. B. F. Fisher, (Westinghouse Lamp Co.), said that in view of the present rapid development of the incandescent lamp the committee was justified in withholding any definite recommendations as to standard practice. He stated that the "vacuum getter" delays blackening of the lamp and increases lamp life and so may cause an entirely different coil test result, accordingly in testing lamps by the forced voltage test, the presence and influence of this vacuum getter must be taken into account. He also stated that manufacturers expected soon to produce tungsten lamps without applying current at any time in the process of manufacture. This will introduce a serious problem of inspection, for the candlepower increases till about 50 hours normal operation.

He stated that the new nitrogen lamp had now been developed to such a state that it is entirely practical for heavy currents and low voltages; it is a question, however, if it will ever be entirely practical for low current and high voltage. The introduction of inert gas will also involve some serious problems of inspection, as well as changing entirely the mechanical construction of the lamp. He said that without doubt, the mazda lamp of the future will operate at between .4 and .6 of a watt per m. s. c. p.

ELECTRIFICATION OF CANADIAN PACIFIC.

The Canadian Pacific Railway has been making preliminary experiments in the Rocky Mountain divisions on electrification. These are preliminary to a large amount of electrification work.

IMPEACHMENT OF SEC. ANDREUCETTI.

As a marked contrast to the interesting programme and enjoyable entertainment of the Convention, we were obliged to consider some serious charges preferred against our previously honored Secretary, J. A. Andreucetti. Mr. A. J. Farrelly, Electrical Engineer of the Chicago & Northwestern Ry., presented the case of the Association, Mr. W. M. Fagan was appointed counsel for the defense, and Mr. F. F. Skeel, prosecuting attorney. The charges preferred against our worthy Secretary-Treas-

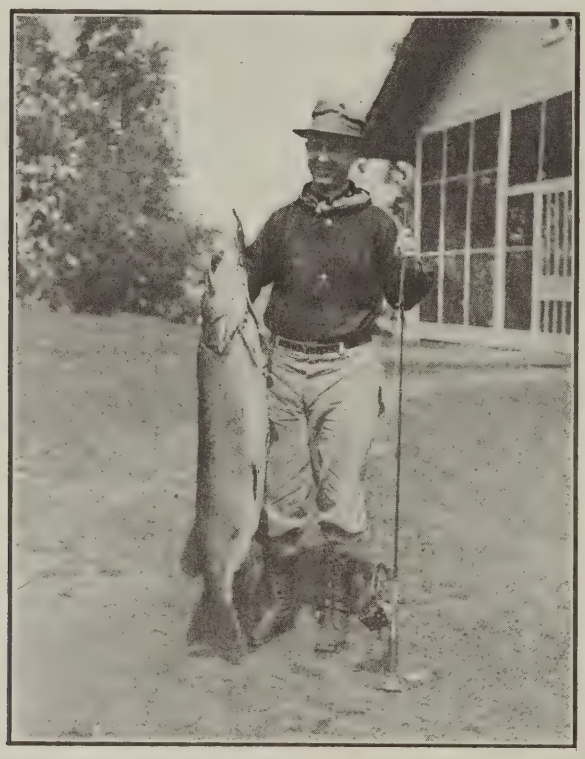


Exhibit "A"

urer, were those of falsifying his records, a very serious charge indeed against one supposed to be the watch-dog of the treasury. The President was several times compelled to request Mr. Andreucetti, the accused, to remain seated and not interrupt the presentation of the charges and proofs.

It seems that about August 25th said Andreucetti caught a fish . . . a big fish . . . up in the woods of Northern Wisconsin. According to prosecutor Skeel, this fish arrived a dripping, bad smelling, proposition for which the expressman parted him from eight or ten dollars. But about the same time a letter arrived from said Andreucetti, to the effect that he had "caught a fish weighing 34 pounds," and hoped that we would have a good feed. But instead of organizing a barbecue, Skeel sent it to a taxidermist and drove a close bargain for mounting a 34 pound fish.

He left for the west that night and when he got to St. Paul received a wire from the "tax" party stating "this fish does not weigh 34 pounds, it weighs 42 pounds, and I want $3.00 more, if I do not get it tomorrow, he goes into the garbage can." Mr. Skeel then presented the direct evidence of the defendant's guilt in a beautifully mounted "musky" that anybody could see weighed over 40 pounds.

Mr. W. A. Fagen, counsel for the defendant, then opened his case, stating that there were two courses open to them. His client could either admit that he did not catch the fish at all . . . that he bought it, and throw himself at the mercy of the court, or he could make the plea of insanity; he recommended the latter course.

Throughout the trial there was a marked uneasiness and embarrassment on the part of most of those present and just at the close of the trial a telegram arrived from Oyster Bay announcing the election of Mr. Joseph A. Andreucetti to honorary membership in the Ananias Club, signed Theodore Roosevelt.

Of course, our worthy secretary tried to offer a plausible explanation to square himself, but———? opinion of the whole court convicted him . . . It isn't very often you get Joe up in the air, but he sure was that day. The President, Cartwright, then presented him an elaborate wreath of honor in behalf of the Association of Railway Electrical Engineers, as the only disciple of Isaac Walton who ever underestimated the size of his fish.

Wednesday Afternoon Session.

Mr. Preston S. Millar, of the Electrical Testing Laboratories, then read a paper entitled "Problem of Incandescent Lamp Testing," prepared by himself and Mr. L. J. Lewinson. This paper contained information of a more or less confidential nature and up to the present time, has not been released for publication. We hope, however, to be able to present this paper either complete or in abstract in our December issue.

A vote of thanks was extended to Mr. Millar and Mr. Lewinson for the interesting paper presented by them. Mr. B. F. Fisher (Westinghouse Lamp Company), pointed out that the light correction factors are based on initial watts per candle and said that the corrections from a forced test to a normal voltage performance is a rather difficult thing, as variables are introduced in the forced test which are not found in normal operation. Mr. Millar added that the Electrical Testing Laboratories are now studying the question of correction factors for the various types and forms of lamp consruction based on the average weights per candle throughout life. This, he stated, would be a more reliable figure than the initial watts per candle, which is dependant to some extent upon the brief ageing of the lamp.

Committee on Wire and Cable Specifications.

This commtitee report, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. W. A. Delmar, chairman. It was pointed out by Mr. F. J. White (Okonite company) that Mr. Delmar had personally spent a great deal of time which involved much personal sacrifice in drafting these specifications, and a vote of thanks was extended to Mr. Delmar for his work in this connection. Mr. Ralph Rice of the Chicago City Railways, and member of the committee on electrical power distribution of the American Electric Railway Association, stated that his committee had been working in co-operation with the committee of this association, for the past year, in an effort to arrive at common specifications or wires and cables. Although the report of his committee was referred back for further consideration, there will be a still further effort to harmonize the wire specifications of the two associations. He said it was their intention to adopt the report of the A. R. E. E. committee in so far as testing of potentials and rubber compound is concerned.

For street railway work, however, this committee felt the need of specifying two grades of insulation, grade "A," 30 per cent Para, and grade "B," approximately 20 per cent Para. He said it was their intention to require such tests as would not only meet the acceptance test at the time of purchase, but that the cable may be up to requirements a year from the date of purchase.

Mr. F. J. White (Okonite company) offered a few exceptions to this report, as follows:

(1) He did not believe that grade "A," first-class high grade rubber, could be made with fine Para. He considered it necessary to specify Bolivian rubber. He said that "smoked first latex" rubber might mean rubber from any source provided it was smoked. He thought that the specifications should be re-worded so as to call for the highest grade of rubber obtainable.

(2) In table 6, the megohm is based on a constant of 4,000. He said that there were few specifications for 30 per cent fine Para which had a constant as low as 4,000. The Railway Signal Association is using a much higher constant and he thought this should be about 9,000.

(3) With respect to test voltages, he said there was a wide difference of opinion. The Okonite company is investigating the subject, especially on very heavy wall insulation, but no two curves agree and the divergence is very wide. He thought it wise to go slow on the matter of test voltages until some more definite information was available.

In answer to the point raised by Mr. White, of indefiniteness of the specifications, Mr. Delmar said that the chemical analysis specified would exclude everything except a very good Para rubber or an exceedingly good Ceylon; in fact it would have to be a very good grade of Para to qualify. He said that the term "First Smoked Latex" is a trade name which refers to a specific kind of rubber, the very best Ceylon or Plantation rubber. As to the voltage test referred to, Mr. Delmar said that Mr. Krass, cable engineer of the New York Edison Company, and Mr. Crater, cable inspector of the New York Central Lines, were responsible for that data. Both of these gentlemen have had a wide experience in high tension cable and the various voltage curves presented by the manufacturers were studied. They did not take simply the voltage of all curves submitted, but gave greater weight to some than to others, according to their judgment, so that the data as presented represented a weighed average of the information submitted by a large number of manufacturers. Mr. White pointed out that there are two or three grades of "Fine Para," one is the "Islands Fine Para," "Up River Fine Para," and "Bolivian Fine Para." The Up River and the Bolivian Fine Para are far superior to the Islands Para. Upon motion the report of the committee was accepted and referred to letter ballot.

Committee on Wiring Buildings.

This committee report, as published in the October issue of the *Railway Electrical Engineer,* was then read by Secretary Andreucetti. In discussing the report, Mr. A. J. Farrelly (C. & N. W. Ry), chairman, said that in navigable waters, where the depth was anything less than 30 feet, a trench should be dredged in which to lay the cable.

A correction was made at about the middle of the second column, page 207, to read as follows: "For alternating current sub-feeders should be at least of 100 per cent larger capacity than the motors they are supposed to serve. It was moved that the part of this report referring to conduit, be eliminated, the specification for conduit published in the 1911 proceedings of the Association to be substituted. Motion carried and the report was accepted as amended.

Committee on Outside Construction and Yard Lighting.

The report of the committee, as published in the October issue of the *Railway Electrical Engineer,* was read by Secretary Andreucetti, in the absence of Mr. H. M. Warren (D. L. & W.), chairman. It was suggested that 125 feet should be made for limiting value for pole spacing, and it was also shown that clamp devices are not always as reliable as the tie wire. It was moved that this be made optional in the report instead of recommending the clamp. It also seems to be the consensus of opinion that the word "danger" placed on a 2,000 or 6,000-volt pole line was entirely unnecessary, for if the installation is properly made a pole line is not dangerous even though the potential carried be very high. Mr. J. H. Davis (B. & O. R. R.) considered that one of the brightest fields of investigation open to this committee for the coming year was that of yard lighting. For with the new nitrogen lamp unit, as high as 2,500 or 3,000 candle power are practical; moreover, the new lamp being essentially a high current lamp would adapt itself very readily to series yard lighting circuits. It was decided to accept the report of the committee as a progress report, and that the committee be continued for next year.

THURSDAY MORNING SESSION.

Committee on Data and Information.

This committee report, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. C. R. Gilman (C. M. & St. P. R. R.), chairman. Mr. Gilman pointed out the advantages to be gained by a properly conducted question box. Mr. L. S. Billau suggested that each chief electrician or electrical foreman make it his duty to get the men in his employ to turn in questions and problems troubling them; these could then be forwarded by him to the editor of the question box. The report of the committee was accepted.

Committee on Illumination.

Mr. L. S. Billau (B. & O. R. R.), chairman of the committee, then read the report, as published in the October issue of the *Railway Electrical Engineer,* and Mr. A. J. Sweet (Vaughan, Meyer & Sweet), was called upon to lead the discussion. He said that although there had been a number of investigations by commercial interests, comparing the different types of reflectors, and although many of these tests have been conducted on the highest plan of reliability and impartiality, this is undoubtedly the first investigation of such magnitude ever conducted by those representing the consumer. Mr. Sweet paid a high tribute to the untiring efforts of Mr. L. S. Billau, (B. & O.), chairman; Mr. H. C. Meloy (L. S. & M. S. Ry.), Mr. L. Schepmoes (Safety C. H. & L. Co.).

As to relative advantages of center deck and half deck, systems, he said that the tests proved there was little advantage as regards distribution and efficiency between the center deck and half deck systems of lighting. The half deck system would be more expensive to install and to maintain, but in certain cases might have greater advertising value. From the strictly artistic standpoint he felt that the center deck system had the advantage, although the half deck system might be more spectacular if properly handled.

As to the spacing of the units he said that the test left no room for argument, two seat spacing being essential. In regard to efficiency, he pointed out that this investigation again established the point that reflectors and globes fall into certain and very definite classes and that within these classes one manufacturer's product may be slightly better than others, but seldom enough better to place it in a different class. He pointed out that the effect of color of the head lining affects the illumination in a car much less than does the color of a ceiling in an ordinary room or office, for the area of the car ceiling is necessarily small.

As to the required intensity for adequate car lighting,

he said that 1.9-ft. candles on a 45-degree reading plane could probably be taken as the minimum service illumination; this would require 25-ft. candles on a horizontal. He pointed out, however, that this should be considered as a service illumination and that the initial installation be figured on a basis of at least 30 per cent depreciation. This would require 2.71-ft. candles on a 45-degree reading plane. From referring to the table on page 165 (October issue) it will be seen that only the mirrored reflector would provide that illumination with the present standard 50-watt lamp. This lamp gives approximately 420 lumens and Mr. Sweet pointed out that there was a great need for a special train lighting lamp of approximately 600 lumens in order to provide adequate illumination of the cars. This would be the equivalent of approxmately a 75-watt lamp.

He stated that the very general use of 15-watt lamps in half deck lighting is positively condemned by the result of these tests. Even with 25-watt lamps at two-seat spacing, and very efficient reflectors, there is barely adequate illumination provided.

To show the accuracy with which the tests were conducted, a repeat test was made using different illuminometers and different lamps in the car, the results of the two tests checked between 1% and 2%. Mr. Sweet referred to the method of determining effect on the eye of a certain type of illumination devised by Doctor Fries, Professor of Psychology at Bryn Mawr College, in which both direct lighting and semi-indirect are shown practically identical as to the question of eye fatigue, both giving a much higher fatigue than in the case of indirect lighting.

Mr. J. L. Minick, (P. R. R.) thought that the data of the tests should be given in regard to a horizontal plane instead of the 45 degree plane, as that is the standard method of rating illumination and should be adhered to. He said that it was pretty well agreed that semi-indirect or totally indirect lighting will give much better quality of illumination, but from calculations he had made he considered it would be necessary to practically double the current supply. This, in many cases, he considered very objectionable. Mr. P. S. Miller, (Electrical Testing Laboratories) highly complimented the committee on the character of the report presented. Mr. Millar said however, that, splendid and successful as the work of this committee had been, it furnished information which bears only upon the second of the 5 factors tabulated, that of uniformity of distribution. He pointed out that this was not a criticism of the work of the committee, but merely indicated the complexity of the problem and the many factors that must be considered. He pointed out that although the committee had shown some excellent results on distribution, it gave no information as to the service depreciation of the various types of car lighting equipment. He called attention to the variance of this committee's report with that published a year ago regarding the diffuse reflecting media. Mr. Sweet said that the results as given a year ago on this point were only indicative rather than conclusive that the units involving specular reflection, such as mirrored reflectors, porcelain enamel, etc., would require 20% more illumination than other types. Mr. Millar stated that he entirely disapproved of the finding of the 1912 committee in this regard. He said it was a fallacy to consider that when there is a lack of diffusion in the illumination, it may be compensated for by increasing the intensity of the illumination; that is, a room or car illuminated by a few brilliant sources of light causes eye strain and fatigue due to glare from reflecting surfaces, such as paper, etc., and this difficulty can not be overcome by simply increasing the intensity of the light as this will increase the glare as well as the general illumination.

Mr. Millar said that when we consider the matter of eye efficiency we are working in a field where the unknown is far greater than the known. He suggested that our illumination committee enlist the co-operation of the Illuminating Engineering Society in planning future researches.

Mr. Sweet explained that the lamps used for tests were carefully selected by manufacturers so as to represent the average filament position and were carefully seasoned and rated. Lamps having practically the same luminous flux were then selected so that the variation in light produced did not exceed 2%.

As to the reflectors, the manufacturers were simply requested to submit samples of such types as they considered best suited for this purpose. From the various types of reflectors submitted the committee selected certain types for test. Mr. Sweet pointed out that the detailed data of each of these tests would be published in pamphlet form and distributed by the Association.

Mr. B. F. Fisher, (Westinghouse Lamp Co.), then spoke of the wonderful development in incandescent lamp manufacture of the past 5 years and said he could see no objection whatever to rating lamps in lumens instead of watts. He said that at the present time it was possible to make a lamp very accurately to a certain wattage and candle power. In fact, the art of making tungsten filaments has developed to such a high degree of accuracy that if the lamps do not show the proper candle power the first thing that is done is to check the photometer.

In reference to article 5 of the committee's findings, which would indicate that a larger lamp than 50 watt would be required, Mr. Fisher said that he would be inclined to go slow on this matter on the grounds of standardization. If we could establish one lamp at one voltage, as a standard, there would be no doubt that the price would be materially reduced, but with all the different sizes now required, he thought it inadvisable to add another unless absolutely necessary. He said, however, that if railroads really want a larger lamp for train lighting it would be supplied. He said, however, that with the rapidly increased efficiency of the present type of lamps, it was entirely possible that the present 50 watt lamp might have a sufficient high candle power one year hence. When asked if it is possible to produce a 75 watt lamp in a G-30 bulb, Mr. Fisher said that this was possible if a vacuum getter was used.

Mr. J. L. Minick (P. R. R.) said that he thought it was a mistake to change the rating of train lighting lamps to lumens instead of watts, as now rated. He said that on inspection of lamps it would be necessary for the inspector to make calculations or refer to curves continually; and the only advantage to be gained by rating lamps in lumens, that of knowing the total light flux of the lamp, could be obtained from his lamp data book. He said that inasmuch as the tests so far conducted, had not taken into consideration the deterioration of the equipment in service, he felt that it would be a serious mistake to request the manufacturers to make an entirely new lamp when that request was based simply on an assumption of 30% deterioration.

Mr. J. R. Cravath, (Consulting Engineer, Chicago) complimented the committee highly upon the excellent material presented in the report. He said that the recommendation of the committee for a light color head-lining, was a very important one. He also said that it is very desirable to avoid sharp contrast between the general illuminosity of the lighting unit and its background,

as such a contrast is one of the principal causes of eye strain. He said that with the center deck lighting, the reader was less liable to be bothered from glare from his paper, as the light is received more obliquely when coming from the center deck than it would from the half deck. He said that one of the striking things shown by the tests is the inefficiency of the present standard practice in our sleeping cars. He thought that with the limitations of present car construction, the best we could do in the way of reducing eye strain is to keep the sources of light well covered by deep reflectors and to have the head lining fairly light so as to avoid sharp contrasts.

Mr. L. S. Billau, (B. & O. R. R.) suggested that either a special committee or the illumination committee for the coming year investigate the following features:

(1) Standardization of filament position with reference to reflectors in car lighting service.

(2) Investigation and recommendation for the limiting screen angle of reflectors for car lighting.

(3) Further investigation of the question of suitable lamp sizes for train lighting service and in connection with that investigation to work in co-operation with the manufacturers. This was then passed as a motion.

(Communicated by Mr. L. S. Billau, B. & O.)

With reference to the coefficiency of illumination of the various head linings tested, a check test has shown that the coefficient for medium olive head lining should be 26.3% instead of 36% and the special white head lining should be 64.6% instead of 88%.

L. S. Billau.

(Communicated by H. B. Wheeler.)

"There is one point which has not been brought out in the committee report or discussion which I believe has a very important bearing on future developments in railway car lighting: all of these tests were conducted in a car having a monitor type roof construction. With indirect lighting the ceiling is a most important factor, and with this type of roof a large percentage of the light freely passes through the deck sash or is absorbed by multiple reflection before it reaches the reading plane. With the turtle back ceiling the efficiency of an indirect system will be increased considerably, from 20% to 30% more light being given to the reading plane than with the monitor type deck.

"As turtle back cars are coming into more general use, the practicability of indirect lighting for cars will be considerably increased."

H. B. Wheeler,
National X-Ray Reflector Co.

Luncheon with the Chicago Electric Club.

On Thursday noon the Association was invited to attend, in a body, the regular weekly luncheon of the Chicago Electric Club, and addresses of welcome and appreciation were exchanged by the Presidents of the two societies.

Paper on the Gas Electric Car.

This paper, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. L. C. Josephs, Jr., General Electric Co. In discussing the paper Mr. Josephs said that any self propelled car can be abused to a far greater extent than is possible to abuse a locomotive. A locomotive when put in service has a definite tonnage and rating and it is impossible to exceed that without being stalled on the road; a self propelled car on the other hand is able to operate at a very high overload and can do so for a short time without injury, but this overload cannot be maintained very long without trouble. He said that men having had experience with axle lighting equipments would appreciate the necessity of keeping the equipment in good running order, and not waiting for it to break down before making repairs. He said that their experience with the electrical departments of the various railroads has shown that the men familiar with car lighting equipment were very well qualified to take care of trouble in the electrical equipment of the gas electric car. The little gas engine knowledge necessary to keep the equipment in operation is soon acquired. He recommended that one man be put in charge of the operation of all the gas electric cars and he be made directly responsible for their operation.

Mr. Hilton, of the Frisco, then gave some very interesting costs on the operation of seven gas electric cars on the Frisco System. The average cost of operation for the 6 months ending in June 30th, 1913, was 18½c per car mile, this including cost of oil and fuel; wages of motorman, conductor, baggage man, and porter; car cleaning and cost of labor and material on shop repairs. The cost given above includes rebuilding the engines and complete repairs to 3 of these cars. For the 6 months previous, these 7 cars operated at 16c per mile, which included all costs as given above and rebuilding one car. He said that certain cars averaged as low as 15.1c per mile for a 6 months period, while some of the others on shorter runs averaged higher.

He described one car which pulls a 30 ton trailer up a two per cent grade more than 4 miles long. He said that this was especially severe service and the water in the radiator was boiling when top of the grade was reached. The popular idea that a motor car is something which is always in trouble is entirely wrong, for with the above mentioned car, operating under most severe conditions, there have been only two engine failures since April, 1912. He said that the cost of reshopping and practically rebuilding a car for 100,000 miles service was in the neighborhood of $1,000.00, in other words, a cost of approximately 1c per mile for repairs to equipment. This when compared with cost of locomotive and car repairs for a train such as the motor car supplants is very low. A vote of thanks was extended to Mr. Josephs for his excellent paper.

A paper on the "Electric Tractor for Handling Freight Cars" was then read by T. V. Buckwalter (Penn. R. R.). as given on page 229 of this issue.

A vote of thanks was extended to Mr. Buckwalter for his excellent paper.

Mr. J. L. Stair, of the National X-Ray Reflector Co., gave an interesting talk describing some of the reflectors made by that company. He showed numerous lantern slides of various types of both direct and indirect installations and said that there were in all about 40 different types of mirrored glass reflectors made to meet various conditions. He said that they recently tested some old reflectors which had been in use more than 12 years and found them to give an efficiency of 80%. He then explained the manufacture of the reflector, which consists of laying a thin layer of pure silver without mercury, on the outside of a clear glass reflector of special form. This silver was then covered with a coating of flexible enamel and baked so as to provide a permanent glazed surface.

FRIDAY MORNING SESSION.

Specifications for Electric Wire Crossing.

The report of this committee, as published in the October issue of the *Railway Electrical Engineer,* was then read by Mr. J. R. Sloan, Chairman.

Mr. William Bennett, Superintendent of Telegraph, C. & N. W. R. R., discussed the subject of the committee report very extensively and pointed out that this was a matter which was usually decided by the various state commissions. He also stated that a somewhat similar specification had been prepared through joint work of the

committee on overhead lines of the National Electric Light Association, the transmission committee of the American Institute of Electrical Engineers, the committee on power distribution of the American Electric Railway Association, and the committee on electricity of the Engineers of the American Railway Association. He said that it was, of course, impossible to dictate to public service commissions, but with a certain amount of tact and such a satisfactory specification as was prepared by the above mentioned committees working together, satisfactory arrangements were usually made.

He complimented the Association on the excellent set of specifications presented in this report and said that they were probably more complete than that of the other committees, but he felt that we should go slow in making any change in standard specifications. A motion was passed to the effect that the report be referred to the committee for next year, with instructions to co-operate with the committee of the other associations mentioned in arranging a satisfactory report on this subject.

Committee on Shop Practice.

The report of the committee on shop practice was then read by Mr. Geo. W. Cravens, (C. & C. Electric Mfg. Co.), Chairman as published on page 234.

Mr. Parker of the General Electric Company, mentioned several instances in which the electric arc welding has been used to great advantage in the shops of that company in repairing large castings, valued at many thousand dollars, that had been broken or were defective; another case in which a tap had been broken off, and by simply welding a nut to the tap it was readily backed off.

Mr Cravens was asked how it was possible to weld overhead and he explained that tiny globules of metal seemed to fly from the electrode to the piece being welded. These globules jump as high as 3/8 of an inch and then stick to the piece being welded. He described a method of welding boiler flues in which the flues project through the sheet about 1/4 of an inch and the weld is made around this projecting portion. He said that when locomotive side frames are cracked the graphite electro is used to cut away a space wide enough to work in and this is then filled in with the metallic electrode. He said that sections as large as 5x8 in. had been welded in this way. It was necessary, however, to heat the other members of the frame in order to prevent stress from temperature contraction. The report of the committee was accepted as read .

Committee on Permanent Specification Forms.

The desirability of having the specifications as adopted by this Association, prepared in loose-leaf permanent form was pointed out by the president, and after some discussion it was decided to appoint a special committee on this subject for the coming year.

FRIDAY AFTERNOON SESSION.

The secretary presented a number of invitations from the cities of Buffalo, Columbus, Ohio, Denver and Philadelphia to hold our next convention in those respective cities and an invitation was presented from the Panama Exposition authorities requesting that our 1915 convention be held at San Francisco.

Secretary Andreucetti said that he felt that it was practically impossible to hold the annual convention there with any degree of success. He said, however, that it would be necessary to advise the management of the exposition at an early date as to our requirements. Mr. J. J. Hack, (Southern Pacific R. R.), said that we would be assured of the best kind of treatment by the exposition officials and pointed out that most all of the conventions of that year would be held there. After much discussion pro and con, as to the advisability of having the convention in San Francisco, it was decided to advise the exposition managers that the consensus of opinion of the present convention was that one of our 1915 meetings should be held in San Francisco if suitable arrangements could be made.

There was much discussion regarding the place of meeting of our semi-annual convention for 1914. It was finally decided to hold this as usual at Atlantic City during the M. M. & M. C. B. conventions, the actual date to be decided later by the executive committee. It was also decided to hold the annual convention of 1914 at Chicago, the time and place to be decided later by the executive committee.

Election of Officers.

Officers of the Association for the coming year were then elected as follows:

President.

Mr. C. R. Gilman, (Chief Electrician, C. M. & St. P.).

Senior Vice-President.

Mr. H. C. Meloy, (Supvr. Elec. Appliances, L. S. & M. S.).

Junior Vice-President.

Mr. E. W. Jansen, (Elec. Engineer, Illinois entral).

Secretary-Treasurer.

Mr. J. A. Andreucetti, (Gen. Foreman C. & N. W. R. R.).

After something of a dead lock in trying to elect two men to the executive committee, Mr. J. J. Hack, (Engr. Tr. Ltg., L. & V., Southern Pacific Co.), Mr. N. E. Lemon, (Elec. Eng. Pullman Company), were elected. Each of the officers elected were then called upon for a short address and Secretary Andreucetti was given one more chance to vindicate himself on his fish story, after which the convention adjourned.

Immediately after the Convention, the new executive committee held a meeting and appointed the committees for the coming year as given on page 24 of this issue.

Entertainment Features.

The entertainment features of this year's convention were particularly successful and well attended. The opening reception and dance, Monday night, drew over 200 couples, and although the East room in which the dance was held was far too small to accommodate the party, the overflow made good use of the halls and cozy corners of the entire mezzanine floor of the hotel. This was entirely informal, being simply an opportunity for getting acquainted and everyone seemed to have a most enjoyable time.

On Tuesday, which had been set aside for an automobile trip, the weather was so disagreeable that it was necessary to postpone it until later in the week. At no time, however, was the weather suitable, so we were compelled to abandon this feature.

Nearly 200 ladies attended the theater party on Wednesday afternoon at the Garrick Theater and saw William Hodge playing in the "Road to Happiness." Souvenir boxes of candy and flowers were distributed by the committee on arrangement.

The fifth annual banquet of the Association was held in Louis XV Room of the Hotel La Salle and there were over 450 people in attendance. During the banquet a cabaret entertainer and quartet, which lead in the singing, made things lively.

Mr. Godfrey H. Atkins, President of the Railway Electrical Supply Mfgrs. Association, acted as toastmaster and offered some very clever stories and introductory remarks. The speakers of the evening were D. J. Cartwright, president of the Association of Railway Electrical Engineers, Bion J. Arnold, and Francis M. Walker.

The Development of an Electric Tractor for Handling Freight Cars Over Tracks Laid on City Streets

T. V. BUCKWALTER

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For many years, possibly half a century, the practice has obtained in certain large cities of operating freight cars over tracks laid on city streets, thus providing for the reception of freight at industrial establishments remotely located as regards main railroad track or sidings. The better equipped factories may have branch sidings leading into their plants, but many have not such sidings and handle material direct from cars spotted in the street.

This practice is even a great convenience, as often the material can be loaded in chutes direct between cars and buildings, affording marked economies over transportation by horse drays or motor trucks between factories and freight stations, as this last-named expense is eliminated entirely.

Electric Tractor for Hauling Freight Cars in City Streets

It has been the practice since the inception of this work to use horses as motive power.

Objections to use of steam locomotives on part of residents located along line of track.

Indifferent success of experiments with steam and electric locomotives.

Failure of experiments with heavy gasoline and electric motor trucks.

Various schemes have been suggested for substituting motive power for horses, as it is acknowledged the use of horses is not in keeping with modern methods of transportation, and the franchises are too valuable to abandon, notwithstanding the constantly increasing cost of operation by horses.

A series of experiments was made, using the most powerful motor trucks, but the writer was convinced by the poor showing of the largest of these trucks that an entirely new design was necessary, several times more powerful than the largest motor truck, and which would compare in power with steam locomotives rather than automobiles. In brief, we were convinced that an entire departure from automobile standards and forms would be necessary.

Further preliminary study developed the following features which should find a place in the projected machine:

The necessity of immense draw bar pull required traction on all wheels.

Simplicity of construction and control limited the design to four wheels.

Convenience of operation required that these four wheels be controlled by steering levers.

"Safety first" compelled braking of all four wheels.

Design of Tractor.

The electric tractor comprises a substantially constructed steel frame with an enclosed cab located at the exact center of the machine and to still further provide for operation in either direction with equal facility, the steering wheel is located in the center of the cab. The controller and brake lever are in duplicate and are mounted on each side of the cab and are conveniently arranged so that the driver can control the steering wheel with one hand and the controller and brake with the other hand. Duplicate sets of controller and brake levers are symmetrically arranged as respects the steering wheel and the machine is general.

The cab is provided with windows on all four sides to provide clear vision in every direction, not only along the track, but also in any direction from which traffic might approach. Standard railroad automatic couplers are mounted on each end of the machine to provide for operation from either end. The machine is mounted on four wheels which are arranged for driving, braking and steering.

Running boards are located on both sides and ends of the machine; in fact, running entirely around except for the space occupied by the wheels. Hand and grab irons extend entirely around the machine and are duplicated at both ends and sides for additional safety to operators. The battery is mounted in a frame below the cab. The weight of the completed machine is 28,850 lbs., and the normal draw bar pull is 8,000 lbs., although the draw bar pull may be increased momentarily to many times this figure. The wheel base is 12 ft. 6½ in., and the tread from center to center of wheel is 7 ft. The overall length of the machine is 22 ft. 8½ in., the width overall is 8 ft. 4 in., and height 11 ft. 2⅜ in.

Driving Apparatus.

The driving apparatus is constructed in duplicate, the drive of each pair of wheels being exactly similar, and a failure could occur in one end of the machine without impairing the efficiency of the other end. Many forms of driving apparatus were considered, using from one to four motors, but the simplest and most substantial arrangement is that similar to the drive on electric baggage trucks, which have been in use now for some years. This device embodies the use of a single motor which drives the steering wheels through double reduction gearing and through the now well known universal pinion, the universal pinion being the only additional part as compared with standard types of drive for ordinary rear axles of motor trucks.

The motor equipment consists of two General Electric No. 1027 series wound vehicle motors, wound for 85 volts and 60 amperes at 900 R.P.M. The weight of the motors and the reaction of the drive is taken directly on the center sills through double universally jointed radius rods. It is not customary to make use of such refinements as universal joints in supporting motors, but was done in this case so that no unlooked-for stresses would be imposed on the driving apparatus and motors. The position of the motor is controlled entirely by the countershaft housing to which it is bolted, and in this manner a permanent and correct alignment of the motor is obtained.

As a further precaution against stresses of an unknown character, the motor pinion is mounted in the countershaft housing and connected with the motor shaft by a flexible coupling of the sleeve type. The countershaft gear, which meshes with the motor pinion, is mounted on a spider supported by the differen-

tial gear casing, which in turn is carried on annular ball bearings in the countershaft housing. The countershaft gear and motor pinion have teeth of the Wuest herringbone type. A distinguishing feature of this gear is that the teeth are cut on one-piece pinions and gears which provide for an exceptionally substantial construction. The motor pinion is constructed of high carbon heat-treated steel; notwithstanding the use of this material, the power to be transmitted requires the use of a countershaft gear which is 31 in. in diameter and 6 in. face. The countershaft gear is shown in Fig. 2.

The driving energy is transmitted to the driving wheels by

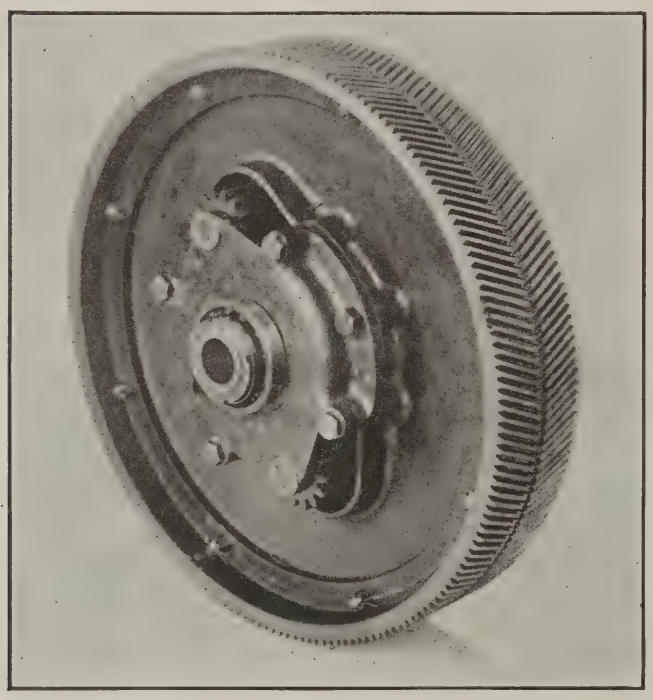


Fig. 1. Herringbone Gear

means of the universal pinions located on the ends of the countershafts. The universal pinion is mounted on the end of the countershaft in the conventional manner and provides an efficient means for driving steering wheels. This function is obtained by locating the center of the universal pinion on the center line of the steering knuckle, as in this manner, while the drive is positive, the angular position of the universal pinion is controlled by that of the driving gear located on the wheel and which, of course, is controlled by the steering gear. The universal pinions are made of high carbon heat-treated steel and are 4 in. in width and 8 in. in diameter. Fig. 2 shows the short countershaft and the universal pinion.

The countershaft housing supports the differential gear, countershafts with the universal pinions, the motor and motor pinions, and thus maintains these important elements in absolute alignment. The universal pinions and driving gears are maintained in relative positions by mounting the countershaft housing in brackets attached to the axle. The driving gear is bolted directly to the spokes of the driving wheel and is 33 in. in diameter and 4 in. in width with 3 diametral pitch. The driving gear is of high carbon steel heat treated.

The driving wheel must stand up under heavy weights and large driving torque, and yet were designed as light as possible. The wheel originally was designed with these points in view and the first wheels were failures due to shrinkage checks. It was apparent that an improvement in design would be necessary or it would be compulsory to use heavy sections similar to locomotive driving wheel centers. The former was decided upon after due consideration and the second set of wheels was made with tangential spokes, as shown in Fig. 3. The theory of this wheel is that the hub will revolve a slight amount ,probably 1 to 3 degrees, while the casting is cooling so that the wheel relieves itself entirely of cooling strains.

The steering knuckle is similar to that used on electric baggage and industrial trucks, and is a departure from common practice in that the bearing is inverted, the object being to shorten or eliminate the hub projection beyond the rim of the wheel, as this is a source of danger on any motor truck required to work in close quarters. Another improvement of the special design of steering knuckle is the short distance from center lines of knuckle and wheel for greater ease and certainty of steering. Fig. 4 shows a sectional view of the steering knuckle and hub of the wheel.

It is important that in all machines driven by storage battery that the most efficient available means be used for the transmission of power, and to obtain this all moving parts, including the motor shaft, motor pinion, countershaft and differential gear and driving wheels are mounted on Hess-Bright annular ball bearings. The bearings in the driving wheel take the radial load only, the thrust being taken on two-direction thrust bearings. The gear ratio between the motor and driving wheel is approximately 38 to 1.

Differential Gear.

The differential gear located in the countershaft housing is thought to be the largest differential gear ever constructed. This construction embodies a new principle in which only four moving gears are utilized, these being two combination pinions, one chain gear and one spur gear. The combination pinions are

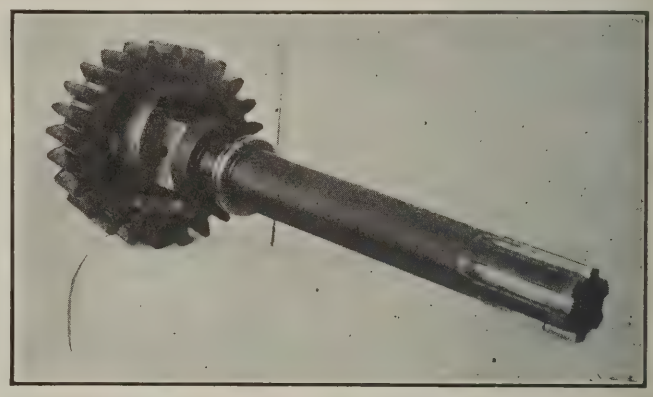


Fig. 2. Counter Shaft with Universal Pinion

mounted on stationary studs and have spur teeth on one end and chain teeth on the other. The pinions are placed diametrically opposite the spur teeth, they mesh with the spur gear and a Whitney chain encircles the chain gear and pinions. The efficiency of this differential is very high, as no energy is lost in the transmission of power from one side to the other and no energy is lost in the thrust bearings.

Tires.

Considerable thought was spent on the subject of tires, as rubber tires were deemed necessary to obtain traction, and it was considered doubtful whether tires could be obtained to stand up under the loads and traction necessary. The expense of the tires in consideration of the probability of damage to tires, led to the use of block tires. It was thought that the question of traction would have a more destructive effect than that of supporting the dead weight, and the tire block was provided with three sections, but were attached to a steel plate

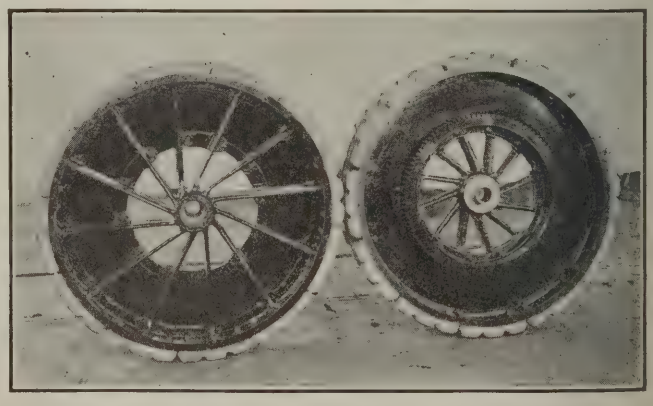


Fig. 3. Tractor Wheels Showing Tangential Spokes

and secured to the driving wheel by 4¾ in. studs. Trouble was experienced with the original tires and they were replaced with tires of a similar base, but the tread was made single, as this latter function was found to be of no value. Tires of the revised shape were obtained from three different manufacturers and two sets of blocks of other shapes and other fastenings from manufacturers, so that at the present time the tires are the product of five manufacturers. Inasmuch as each wheel is of the same weight and as each wheel does exactly the same work, this tire trial should prove of interest when definite information

is available. An examination of the tires is made monthly and the condition noted. The manufacturers may be designated as A, B, C, D and E, and the condition of these makes as regards general condition change from month to month. Thus far no one make has appeared to be in rank first as regards condition for a longer period than two months.

Steering Apparatus.

The steering apparatus was thought to be one of the most important mechanisms on the electric tractor, and was the subject of much thought in order to obtain a high degree of reliability. Other features which were given consideration was the method of steering or the desirability of having the steering wheel arranged so as to become an indication of the direction of travel, that is regardless of the direction of travel, and the position of the operator in the cab, the movement of the upper portion of the steering wheel to be an indication of the direction of travel.

The steering gear housing is mounted a trifle towards one end of the exact center of the machine so that the steering wheel is brought in the exact center. The steering wheel is mounted

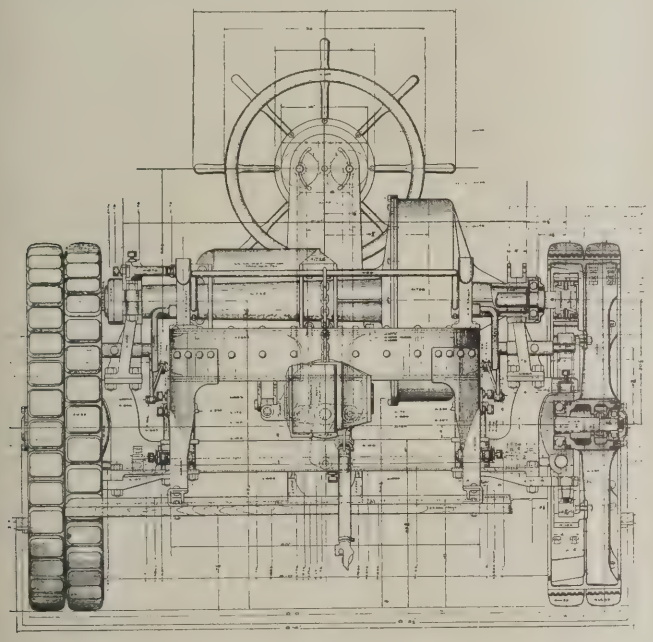


Fig. 4. Sectional View of Steering Knuckle and Wheel Hub

on a steering shaft on which is cut an integral pinion and which is mounted on annular Hess-Bright ball bearings. A good idea of the steering wheel may be obtained from Fig. 4. The wheel is constructed with hickory spokes and walnut and mahogany rim. The spokes in this steering wheel are continuous without reduction from the handle to the hub, to which they are bolted. The diameter of the wheel over the rim is 32 in. and over the spokes 42 in., being possibly the largest steering wheel on a motor truck. The steering gear from the wheel to the steering knuckle will withstand any effort that a man can impose on it with an ample factor of safety to all parts.

The steering reduction is obtained in the steering gear housing. This reduction consists of the wheel pinion which meshes with a pair of planet gears engaging with a stationary annular rack. The planet gears are supported entirely by the pinion and rack and are connected by means of steering rods to crank pins mounted in a built up steering shaft located vertically below the steering gear. These pins are located oppositely as regards the steering shaft and have the same center distance as the planet gears. It is apparent, therefore, that any motion imparted to the wheel is transmitted positively of the steering shaft. This steering shaft extends longitudinally of the tractor and carries downwardly projecting arms at each end which connect through double universally jointed steering rods to the steering arms which are similar to those used on heavy motor trucks, except that they are somewhat larger. The strength of the steering arms may be gathered from the fact that the steering link connecting the steering knuckles is 2 in. with ¼ in. wall nickel steel tubing. All pins and bushings in the steering gear are hardened and ground

A certain degree of flexibility is absolutely essential in any heavy motor truck, increasingly so as the weight increases. The desired flexibility is obtained by making the longitudinal shaft of chrome vanadium steel. The amount of flexibility may be gauged from the fact that the weight of the driver on the steering wheel will deflect this shaft sufficient to move the steering wheel about 15 degrees. The machine has been in practically constant service since January 4, 1913, and to date the steering gear has not developed any back lash whatever, that is, no back lash can be noticed at the rim of the steering wheel. If this fact be compared with the back lash that develops on standard automobiles after a few weeks' use, it will form conclusive proof of superiority.

Braking Apparatus.

As one of the important reasons for the substitution of motive power for animal power was that of obtaining a more reliable and efficient braking system, it is but natural that the subject of braking on the electric tractor has been given a great deal of thought. The weight of the tractor is very much greater than that of ordinary heavy commercial trucks, imposing greater responsibility on the brake apparatus. This, with the thought that the efforts of a man with ordinary strength is necessarily rather insignificant in making an application of brakes on a machine of this size, led to the decision to make use of a power brake and air was selected as the most satisfactory medium. As the matter was gone into deeper, it was found necessary to elaborate considerably as regards the braking apparatus beyond our original plans. For instance, the simplest form of power brake as regards the tractor would be straight air, but unfortunately the air brake equipment on freight cars is arranged for automatic air, and as the use of automatic and straight air would simply complicate matters, it was decided to use automatic air on both the tractor and on the train.

The principal features of the air brake system will be described under their respective heads.

Compressed air is furnished by a standard G. E. 125-volt, C.P.-27 motor driven air compensator of 15 cu. ft. capacity. The compressor is located in the corner of the cab beneath the switchboard, as may be seen in Fig. 5. The construction is too well known as to require further description, except to mention that it is of the self contained unit type, in which the armature pinion meshes with the two-piece type of herringbone

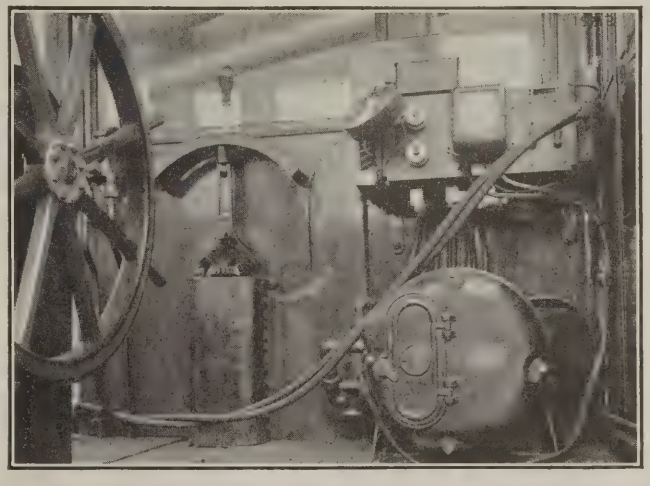


Fig. 5. Steering Wheel, Switchboard and Compressor

gear secured to the crank shaft between the cylinders, the machine being of the two cylinder single stage type. It would have been possible to have combined an air cylinder with some part of the transmission mechanism and some small percentage of power might have been saved when the machine is in regular service. With due consideration of the fact that the machine would be required to do considerable shifting and would require a large volume of air for braking, while at the same time little ground would be covered in running, it was decided to follow the "safety first" plan and provide a separate air compressor.

The air compressor governor is the General Electric type ML, Form A, and is set to operate regularly at about 90 to 95 lbs.

The main reservoir is 10 in. in diameter and 108 in. long, and was furnished by the Westinghouse Air Brake Company, and is located longitudinally below the center sills at about the center of the machine.

The brake cylinder is located beneath the floor of the cab above the frame and is shown in the attached photograph of the general plan. The brake cylinder was designed especially for this machine and is 4 in. in diameter. A standard Westinghouse F-1 (H-24) triple valve regulates the movement of air to the brake cylinders.

An especially designed auxiliary reservoir is located in close proximity of the brake cylinder which is also controlled through the triple valve.

Brake valves are provided in duplicate, inasmuch as the operation of the brake valve is entirely independent of other brake valves in the same system, avoiding the necessity of any interlocking device. The brake valves are mounted within easy reach of the driver's left hand.

Before proceeding with the description of the brake foundation gear, it may be in order to describe the functions of the brake apparatus previously mentioned. The brake apparatus is set in motion by closing a switch to the compressor governor, whereby the compressor stores air in the main reservoir until a pressure of 95 lbs. is reached, when the governor is tripped and cuts off the current to the compressor. When the air drops to 90 lbs. the governor switch is again closed and starts the compressor. Air from the main reservoir acts against a small piston in the triple valve, forcing it to the limit of its travel. This movement opens a by-pass which admits air until a balance is obtained between the main and auxiliary reservoir. Air is also admitted at this time through the triple valve to the train line which is connected to the train, and which is also connected to the brake valves. Braking application is effected by releasing air from the train line which disturbs the balance between the main reservoir and train line and causes the movement of the above mentioned piston proportionate to the amount of air reduction. This operates a small valve in the second portion of the triple which admits auxiliary reservoir air to the brake cylinder, thereby making an application. If the train line pressure is discharged suddenly either by rupture of the hose or emergency application by the brake valve, the pressure between the auxiliary reservoir and the brake cylinder instantly balances, and as the auxiliary reservoir has about three times the volume of the brake cylinder, a brake pressure of about 70 lbs. is obtained. The brake is released by recharging the train line by reverse movement of the brake valve which operates the piston in the triple valve and recharges the auxiliary reservoir, and at the same time exhausting the air in the brake cylinder. A diagram of the brake connections is shown in the attached photographs. While the operation may appear complicated, it is in reality a remarkable, simple and efficient braking system, and it is believed that brake application is effected in about 1/50 of a second from the time of opening of the brake valve.

Placing the brake lever in the lap or central position retains the power in the then occupied position. The brakes can be released only by placing the lever to the release position. A very sensitive brake application can be obtained, as a reduction of 5 lbs. in the train line will make an application of approximately three fourths this pressure in the brake cylinder and this can be held until released.

The brake foundation gear consists of a system of levers and rods whereby the braking force is divided and applied equally to the brake shoes on each of the wheels, the brake gear being entirely equalized. The foundation gear is designed so that fracture may occur on the brake shoes or rods leading to the brake cams or wheels without affecting the other wheels. An outline of the brake foundation gear is shown on the diagram of brake piping.

Standard air brake apparatus must have a working fulcrum at the opposite end of the brake foundation gear from the brake cylinder. This foundation gear, however, does not have a fixed fulcrum, but has what might be termed a variable fulcrum, the operation of which will be described under the heading, controller apparatus.

A two-piece internally expending brake shoe operates on the inside surface of each driving gear. The total braking surface is 30 in. in diameter and 10 in. wide, having an area of approximately 940 sq. in., or over 6½ sq, ft. A series of tests was made to determine on the proper material for the brake shoe lining. Our experience indicated that a woven asbestos fabric was not satisfactory for this surface; while it has other good qualities, it is objectionable because the alternating stress due to double end control tears it from its fastening. This compelled the use of metal lining, the important qualities of which would be: absence of cutting of the brake band, braking without lubricant, and a smooth application of the brake without gripping. The matter was not considered solved until a metal was discovered which consists of simply copper saturated with lead, which forms a material resembling cast iron in its properties, in that the material gradually wears away in a finely powdered form. The lining is superior to cast iron, however, in that the brake band is never cut.

The halves of the brake shoes are operated by a conventional cam and a specially designed and patented connection between the cam and brake shoe which permits the operation of the brakes on the steering wheel, and except for this simple detail, which consists simply of a divided cylindrical pin attached to the brake shoe, the brake is not any more complicated than that on standard rear wheel automobile construction.

The brake apparatus was carefully designed so that the maximum braking power would be obtained without danger of slipping the wheels, as the practice of slipping the wheels on automobiles is highly dangerous, and it should in all cases be avoided as no dependence can be placed on operators for smooth application of the brake.

A hand-operated device consisting of a hand wheel and ratchet is provided for application of the brake by hand. This device is supplementary to the air brake and interferes in no way with the latter.

The tractor is provided with a train line with air hose at each end which are mounted on radial draft gear. This air hose may be connected to the train line of the draft of cars and the operation of the brakes of the cars and tractor is then simultaneous. The relative capacities of the brake cylinder and auxiliary reservoir and piping between the two was carefully designed in order to prevent surging stresses between the tractor and train when applying the brake. It may be in order to state that applications of the brake have been observed in a coupled train in which the train was stopped without taking the slack out of the draft gear.

Controlling Apparatus:

The controller is mounted on one side of the cab, this being of standard General Electric design, proportioned especially for handling the two motors. The controller provides three speeds in either direction which are exactly symmetrical. The first speed places the two motors in series across the battery circuit in series with the resistance; the second speed shunts the resistance, and the third speed connects the motors in parallel. A transition step is provided between the second and third speeds to break the arc due to changing over. The first speed is intended for very slow running, as when the tractor must be moved from one inch to a few feet in coupling. The instructions are to dwell on the first speed from one to two seconds to enable the mechanism to be put in motion before passing to the second speed, which is the running speed for use in heavily congested street conditions or for any reason where a speed of from 3 to 4 miles an hour is desired. The third speed is the ordinary running speed and provides for a speed of 6 miles an hour with a loaded car on level tangent track. The tractor will run above this sped, but should be kept below 7 miles an hour at all times, as at this speed the tractor or train of cars can be stopped in from 6 to 10 feet, depending upon track conditions.

Though a single controller is provided, mechanism connected through spur and bevel gearing is provided for controller connection to the opposite sides of the cab so that the brake and controller can always be operated by the left hand. The use of a single controller effects a considerable saving in wiring connections and loss of power through the main leads. While the controller is of the drum type, it is connected by geared quadrants to the control lever which has a movement in the forward and aft direction. The controller is invariably moved in the direction of travel whether for forward or backward operation.

The controller handle is removable and may be inserted in either of two sockets in the controller levers. Each socket registers with a slot formed in the guard above the controller levers and to reverse the controller the handle must be changed to the neutral position and inserted in the other socket for operation in the other direction.

The controller handle shaft connects the controller levers. This shaft is placed crosswise of the machine immediately beneath the floor, and carries a chain pinion at about the center. A roller chain encircles the pinion and is secured at both ends to the variable fulcrum of the brake gear. Operation of the controller in either direction winds up one or the other end of the chain, imparting a movement to the variable fulcrum. When the brake is applied by hand or by air a fixed fulcrum is not obtained until one or the other of these chains revolves the controller shaft to the neutral position. When a solid fulcrum is obtained through both ends of the chain, this movement returns the controller to the neutral position. It is evident also that the controller cannot be moved from the neutral position until the brake is released.

A combination Weston meter is mounted on the switchboard, the voltmeter reading to 250 volts, and the ammeter reading to 200-0-1000.

The charging plug is a special cylindrical design of 200 amperes capacity. The discharge and charging current is controlled through a Sangamo ampere-hour meter with dial reading to 600 ampere-hours. Fig. 5 shows the switchboard apparatus. An air whistle operated by overhead cord and electric gong operated from either of two foot buttons provides ample warning. The warning signals are highly essential, as the special gearing on the machine makes less noise than the average touring car. The lighting system

consists of 6-volt, 20-candlepower, dome light and one 6-volt, 20-candlepower concentrated filament headlight at each end.

Heat Treatment:

Axle steel forgings are used on all essential parts of the driving, braking, steering and control apparatus, and all of these forgings are subjected to one of three forms of heat treatment. Parts subjected to wear were carbonized and heat treated. Parts subjected to shock only received a double refining heat treatment. Other parts subject to stress or flexure were tempered to a spring temper. All pins and bushings in the steering and driving gear were ground to size and fitted with from one to two-thousandths of an inch tolerance. All pins and bushings in the brake and control apparatus were hardened, but not ground. Thus far there has not occurred a single failure of any part that was heat treated according to specifications, although the first steering knuckles failed in service, due to the fact that the heat treating specifications were not adhered to. The second set of steering knuckles was heat treated according to the formula and have given no trouble, notwithstanding the fact that the machine operated about three weeks without tires.

Battery:

The battery is composed of 80 cells of Edison A-12, being the largest size commercial battery, having a capacity of 450 ampere-hours, or 90 amperes for 5 hours. The battery is arranged in two parts assembled in trays of 5 cells each. The battery frame is placed immediately below the floor of the cab and is accessible by opening the battery box doors. The battery is arranged in two parts for convenience in charging. The battery box is lined throughout with compressed cork furnished by the Armstrong Cork Company. This cork lining has successfully withstood the action of the alkali solution used in the battery. The battery provides for about 16 miles operation on one charge, but this figure should not be compared with the radius of action of a commercial truck, for the reason that the tractor will often have trailing loads of 80 tons to handle over 2 per cent grades and 50-foot radius curves, or it may be coupled to trains of 300 or 400 tons weight on grades up to 2 per cent.

Draft Gear:

Radial draft gear is provided on each end of the machine. The draft gear is of substantial construction, being designed along the same general lines as the interurban steel passenger cars now coming into general use. The draft gear is pivoted to substantial steel castings riveted to the ends of the center sills and provides for a swing of about 35 degrees on either side of the center line. A pivoted coupler head of standard design and weight is mounted on the end of each draft gear. This provides for coupling to the fixed draft gear of freight car equipment on any degree of curvature in which it is possible to operate cars. A powerful spring arrangement returns the draft gear to the central position. A heavy spring 8 in. in diameter made from 1 5/16 in. stock takes up the shock of pushing and pulling. The pressure required to close this spring is 10,400 lbs. and the limit of action is 3 in. in either direction from the normal position. Photographs of drawing showing the section of draft gear is attached.

Frame:

The frame is of a very substantial steel construction. The center sills are of 7 in. 12¼ lb. channel. These sills do not extend the full length of the machine, but terminate in the draft gear pivot. The cross sills consist of 7 in. 15 lb. "I" beams which retain the center and side sills in correct alignment. The end sills are of pressed steel having a maximum depth of 8½ in., width of 6 in. of ⅜-in. plate. The outer portion of this channel section is braced against collapse by the inner portion of trough section.

The battery box is built onto the frame and is divided into two sections and lined throughout with ⅛-in. plates. The tractor frame is carried on semi-elliptic springs of the locomotive type, the springs being 3 in. wide and 54 in. long. Inasmuch as the springs have been calculated to carry the weight of the machine only, it is possible to obtain a very smooth riding quality.

Cab:

The cab is mounted in the center of the machine and is of steel throughout. The outside dimension is 7 ft. 6 in. by 7 ft. 0 in., the walls being approximately 2 in. thick, consisting of outer lining of ⅛ in. inner lining 3/32 in. plate with pressed steel "D" members between, these being located at the corners and between the windows. The doors are also of steel and are located at diagonally opposite corners. The windows extend practically around all four sides of the cab, except for the space occupied by the corners and standards. The roof is composed of wood covered with specially treated and painted canvas. This material is cooler than any other material available.

RESULTS OF OPERATION:

AVERAGE DAILY PERFORMANCE OF ELECTRIC TRACTOR BY MONTHS

1913 Months	Hours on Charge	Hours in Service	Discharge in Ampere Hours	Miles Run	No. of Cars Handled in	No. of Cars Handled Out	Total	Total Wt. Tons	No. of Inter-nal Mov'm'nts	Days in Serv.	Days Out of Service	
Feb.	8.2	8.5	616	12.1	14.8	14.8	29.6	992	19.5			
Mar.	7.3	8.5	508	12.6	15.3	15.0	30.3	1,032	19.4			
Apr.	7.9	9.5	518	13.7	15.7	16.5	32.2	1,100	20.9			
May	7.27											
June	6.7											
July	6.0	7.7	410	14.4	14.4	14.4	28.7	962	13.6			
Aug.	5.5	6.7	344	10.3	11.4	11.4	22.8	763	14.3			
Daily Avg.	6.98	8.28	486	13.0	14.9	15.0	29.9	1,003	17.0			
TOTALS BY MONTHS												
Feb.	164	168	12,120	241.5	297	296	593	19,842	390	20		
Mar.	190	220	13,230	328.3	398	390	788	26,837	504	26		
Apr.	166	199	10,890	280.9	330	346	676	23,082	438	21	5	
May	160	186	11,225	325.0	375	375	750	24,600	380	22	4	
June	167	215	12,330	327.9	393	397	790	26,433	351	25		
July	156	199	10,430	303.7	374	373	747	25,005	354	26		
Aug.	144	174	8,940	268.7	296	295	591	19,775	371	26		
Total for 7 Mo.	1,147	1,361	79,165	2,076.0	2,463	2,472	4,935	165,574	2,788	166	9	

COST OF MAINTENANCE AND OPERATION

Month	Repairs	Supplies	Lubri-cation	Chauffeur Labor	Current	Total
February	11.78	2.02	1.13	139.10	91.38	295.45
March	100.82	6.40	1.18	105.18	94.45	308.03
April	183.86	13.38	1.55	125.89	92.19	416.87
May	548.38	3.67	1.58	141.52	122.05	817.20
June	894.94	9.43	1.12	140.88	73.97	1,120.34
July	59.36	2.59	8.10	146.09	103.39	319.53
August	16.71	5.01	2.82	161.85	96.40	282.79
Total for 7 Mos.	1,815.85	42.50	17.48	960.55	673.83	3,510.21

Cost of maintenance and operation 7 months	$3,510.21
Interest at 6% on $13,400—7 months	476.00
Depreciation on $13,400 (less tires and battery 4200=9200) @ 5%—7 months	268.33
Depreciation on battery $3,200 @ 20% for 7 months	373.34
Total charges for 7 months	$4,627.88
Total charges if horses had been used (4,935 cars × $1.86)	9,179.10
Saving by electric tractor—7 months	$4,551.22
Saving over investment by electric tractor	58.5%
Saving including investment 58.5 and 6%	64.5%
Cost of service per car ($4,627.88÷4,935)	.938
Cost of service per ton ($4,627.88÷165,524)	.028
Average number of cars per mile	2.4
Cost of service per ton mile (.028×2.4)	.067
Total number of cars handled (4,935+2,788)	7,723
Number tons handled per hour	121
Cost of service by electric tractor per working day.	$ 27.87
Cost of service by team per working day	55.29

The above tables indicate that the machine has handled a total of 4,935 cars in the seven months, from February to August, inclusive, at a cost of $4,627.88, including all capital, maintenance and operating charges. The cost of handling this number of cars by horses would have been $9,179.10, thus indicating a saving by use of the electric tractor of $4,551.22, or 64.5 per cent on the investment of $13,400.00.

It will be noted that the cost of operation is regular at from $300 to $400 per month, except the months of May and June when the repair charges are considerably higher. This is due to the replacement of the original tires and steering knuckles, which was done in April and the first four days in May.

Tire Expense:

The original design contemplated the use of continuous tires, but it was found that the cost of these would be excessive, as would also the cost of replacements in case of minor accidents to tires. A tire was therefore designed embodying the use of blocks 6x14 in. in size, arranged 24 to a wheel in two rows of 12 each. The tread is vulcanized to a steel base through the medium of a layer of hard rubber. Each steel base is secured to the wheel by four ¾-in. studs.

It was our thought originally that each block be divided into three sections to obtain better traction, which was attained, but at the expense of load sustaining capacity. The tire contract was placed with a firm which had been quite successful in making small truck tires. The tires showed signs of weakness during the first months for two reasons. First, on account of the use of too much pure rubber, which

had the effect of reducing the sustaining power. Second, a similar effect from use of sectional tread.

The design was therefore changed to utilize a single tread to each block and equipment for a complete wheel was obtained, one from each of two standard tire manufacturers. The other two wheels were equipped with block tires designed by the tire maker, one wheel being assigned to each of two makers. As each wheel carries an equal weight and does an equal amount of work, an exceptionally fair test is under way. The replacement of tires commenced early in April and was completed May 5th. Pending the receipt of new equipment, the machine operated a couple weeks on tires made by widing 7-in. circumference rope over the rim of the wheel. All of the new tires are giving good results and the experience thus far obtained leads us to expect one and one-half to two years service per set.

Steering Knuckle Failure:

The original steering knuckles failed on account of being burnt in heat treatment, due to misunderstanding between the day and night forces. A loss of service of nine days was entailed in replacing the burnt knuckles. This was accomplished on May 5th, and since that time no service has been lost and the failures have been confined to minor items, such as breakage of air hose, lamps, etc. Omitting the cost of the above mentioned replacements, the saving on the investment would be over 80 per cent.

Speedometer:

A speedometer equipment was not originally intended as part of the equipment, but the desirability of information on tires, etc., made it practically a necessity. Due to the peculiarities of the automobile industry, it was found cheaper to provide a combined speedometer and odometer than the odometer alone. An instrument calculated for slow speed vehicles was also not obtainable, but an instrument reading to 80 miles an hour was geared up ten to one, thus providing accurate readings to 8 miles per hour.

Conclusion:

The above description portrays our experience with the electric tractor as accurately as we can make it. Some troubles have been encountered, but we believe the finished machine is superior to any that could have been obtained or can now be obtained from any industrial manufacturer. Notwithstanding it is the progenitor of its type, the service performed has been uniformly more satisfactory and the financial results more encouraging than those connected with its design and operation expected.

Report of the Committee on Shop Practice

Report for the Year 1913

After a careful consideration of the present tendencies in Railroad Shop Practice, together with a thorough canvass of possible subjects for discussion in connection with this report, your committee decided it would be better to deal with a few of the more important ones instead of attempting to cover the entire field or to confine the report to certain subjects.

We have, therefore, chosen electric arc welding, reversing motors and automatic control as the principal subjects, with some few references also to motor economy and standardization. We realize, of course, the utter impossibility of fully and completely covering all of these subjects in a report of this nature, but, if we can suggest enough of interest to bring out a full and lively discussion of them we shall feel that our work has not been in vain.

Electric Arc Welding.

There are several processes by which electricity is used for the joining of metals—spot welding, or joining comparatively thin metal by heating in spots and applying pressure; butt welding, or the joining of moderately large sections end to end by a similar process; and arc welding, or the joining, filling up holes in or building up parts or entire pieces of metal through melting additional metal into place with the electric arc as a flame. Spot welding has found but limited use, thus far, in railroad shops; butt welding has been used somewhat more for making rings, tires, long bars, tubes, etc., and arc welding is being used by a large number of shops for the above purposes in addition to repairing cracks in sheets and castings, filling bad spots, welding in boiler tubes, building up broken lugs, etc. It is this use of electric welding that we will deal with herein.

The electric arc is used in railroad shops for welding by two processes, one being known as the Bernardos and the other as the Slavianoff process, being named after the men who have done most to perfect them. The Bernardos process consists in drawing the arc between the piece worked upon and an electrode of carbon or graphite, using the arc the same as a gas flame for melting proper filling materials into place. This process is gradually being called simple "Graphite welding," and is suitable for all of the heavier kinds of welding, the arc also being used for cutting as with acetylene. The Slavianoff process consists in using the work as one terminal for the arc, in a similar way to the other, but using a piece of the filling material as the other electrode and melting it into place direct. The metallic electrode is usually in the form of a piece of wire of the proper composition, and is held in a suitable holder somewhat smaller than for the graphite electrode. This process is becoming known as "Metallic welding" and is especially suitable for light work, boiler tubes, sheet metal, etc.

With both of these processes the work is made the positive terminal of the arc and the electrode the negative, because the positive crater of an arc is always the hotter and this insures the work being warm enough to prevent chilling of the filling material. This is one reason electric welding is gradually superseding acetylene welding in so many railroad shops. By proper selection of the filling material the weld may be made of the same hardness and composition as the part worked upon, and full strength may be obtained in most cases by proper manipulation while welding.

Owing to the very sensitive nature of the electric arc it is of great importance that the source of current supply be controlled as positively as possible, and experience shows that a motor-generator set is the best means of getting good regulation of the supply. This also provides a satisfactory means of operating from alternating current feeders, because a direct or continuous current is required and rotary converters provide very poor voltage regulation. They have been tried with but indifferent success, so about 90 per cent of the electric arc welding machines in use today are motor-generator sets.

The use of resistances in the form of groups of iron grids or water barrels has been tried in some shops, but this is very wasteful because the best voltage for arc welding is around 70 to 75 volts. Experience also shows that unless some means is provided for the independent control of each welding circuit it is not practicable to attempt to operate more than one circuit from a single source. This has made those systems using automatic control the most satisfactory, and a large number of railroad shops have adopted them.

With the Bernardos system, using a carbon or graphite electrode, the current required will range from 100 to 800 amperes per circuit on the welding or low voltage side, the line current depending upon the efficiency of the apparatus and the line voltage. With the Slavianoff system, using metallic electrodes, the current will vary from 20 to 200 amperes, depending upon the nature of the work, the size of the piece being manipulated and the material. The usual operations with the metallic electrode, however, require but from 40 to 100 amperes, and with the graphite electrode from 300 to 500 amperes, the latter being frequently used for cutting purposes.

Electric arc welding is being used in railroad shops today for repairing iron, steel, copper and aluminum castings, forgings, tubes and sheets; forged steel locomotive frames, axles, tires, side rods and valve gear; cracks in fire boxes, flue sheets, cylinders, wheels, journal boxes, tender and truck frames, welding in flues, side seams, mud rings, fire door frames, attaching heads, heating rivets and stay bolts, cutting holes in boiler sheets, cutting and joining bars in forge shops; building car frames, putting on the sides and roofs, making one piece roofs, attaching interior and exterior trim, making up complicated sections of piping, truck bolsters and the hundreds of other operations involved in the joining and repairing of metals. In foundries the carbon arc is used for cutting off risers, gates, fins and filling in sink heads, sand holes, cold

shuts, missing parts, and welding shrinkage cracks, thus reclaiming a large amount of spoiled work and saving valuable time as well as money.

The cost of welding with the electric arc is lower than by any other method, usually being about one-third that of the gas systems, and the time required, being about one-half for similar jobs. This applies to the oxy-acetylene, oxy-hydrogen and blau-gas processes and is due to the higher cost of the gases as well as their lower temperature, and the difference in favor of the electric system is still greater when compared with Thermit welding.

There is so much to be said regarding the use of this system in our shops that your committee hopes each member may give us the benefit of such experience as he may have had. There are nearly 1,000 locomotives running on American roads today with some part electrically welded and one of the largest locomotive builders has several welding outfits in constant use on new engines, so the system has passed beyond the experimental stage far enough to warrant us in recommending that this kind of apparatus be made a part of the equipment of every railroad shop.

Through the courtesy of the leading makers of this apparatus, we are enabled to give the following figures showing the cost of electric arc welding as actually done in several railroad shops with their apparatus.

Time and Costs of Various Repairs.

Steel casting, crack 6 in. long by 1 in. deep	8 min.	$ .04
Steel casting, riser 4 in. by 4 in. cut off	4 min.	.05
Forged steel locomotive frame, 2 breaks	20 hrs.	18.28
Crack 12 in. long in boiler sheet	9 hrs.	5.47
Cast steel tender frame, 3 breaks	27 hrs.	19.00
Broken railway type motor case, cast steel.	3 hrs.	1.95
Enlarged holes in brake levers, steel bars	4 min.	.05
Air brake piston rods, broken	30 min.	.35
Cracked axle boxes, welded in place	15 min.	.15

Savings by repairs instead of Replacements.

Armature shaft repaired in place, worn journals	$13.16
Railway motor axle cap, large, cracked	3.29
Railway motor armature bearing cap, broken	5.80
Railway motor gear case, top half broken	6.82
Truck side frame, Brill 27-G, broken	43.68
Truck side frame, Peckham 14-B, broken	46.08
Motor frame, GE-90, railway type, cracked	13.92

Saving by Electric Arc Welding instead of Old Method.

Engine main frames, both broken	$ 44.40
Driving wheel built up on tread 3/16 in.	7.28
General repairs on fire box side sheets	276.11
Filling in worn knuckle joint bushing hole	6.75
Locomotive cylinder casting, 7 cracks	344.50
Broken mud ring on locomotive boiler	85.99

These electric arc welding outfits are in continuous use today in the shops of the Central Railroad of New Jersey; Michigan Central; New York, New Harven & Hartford R. R.; Delaware & Hudson; Philadelphia & Reading; Kansas City Southern; Buffalo, Rochester & Pittsburgh; South Manchurian Railways; Canadian Northern; Pennsylvania Lines; Chicago & North-Western; Baltimore & Ohio; Chicago, Indiana & Southern; Philadelphia, Baltimore & Washington; Cincinnati, New Orleans & Texas Pacific; Central of Georgia Railway and many others, in addition to the plants of the American Locomotive Co., Harlan & Hollingsworth, Pettibone-Mulliken Co. and many other makers of railroad equipment.

Reversing Motor Drives.

Among the many important changes in shop practice due to the wide spread application of electric motors there is probably none of greater importance than those due to the application of automatic reversing motor drives to planers, shapers, slotters, etc. While a great many shop men appreciate the great saving in power and the increased production due to this practice, it is doubtful if the true importance of it is fully realized. Usually, the saving in transmission losses is the only thing considered and, even though this may be 50 or 60 per cent of the total power required, it is often only a small part of the real saving. The principal gain is in the increased production and decreased cost.

It is easily seen that the most efficient tool is the one which will do the most work in a given time without straining either the tool or the work; do it accurately and at the lowest cost for power and maintenance, and with the least loss of lime between cutting operations. With tools that perform their work with a rotary motion of either the cutting tool or the work, such as lathes, boring mills and drills, it is possible to make the tool work 100 per cent of the time it is running, but with tools that operate with a reciprocating motion of either the cutting tool or the work, such as planers, shapers and slotters, a portion of the time is lost when returning between cutting strokes. So, the relation of cutting strokes and return stroke has an important influence on the amount of work that may be done in a given time.

With the direct coupled automatic reverse drive the cutting and returning speeds are controlled independently, so it is possible to make the ratio between return and cutting speeds anything that may be desired, up to the practical limit. The speeds commonly employed for planing range from 50 to 100 feet per minute for the return stroke and from 25 to 50 feet per minute for the cutting strokes, the speeds depending upon the nature of the work.

From this it will be seen that the average ratio between the return and cutting speeds will be 2 to 1, and motors giving this ratio are easily obtained. But, if a ratio of 3 to 1 is obtained there will be a gain of 12½ per cent in time required to do a given amount of work, while with a ratio of 4 to 1 the gain will be 20 per cent. We find, however, that the latter is hard to obtain unless the planer is made heavy enough to stand this service, on account of the shock produced in accelerating and stopping the platen or table when the speed exceeds 100 feet per minute.

As a great many of our members are responsible for choosing the motors for this service, your committee feels that any data which may be available should be brought to these conventions for discussion. This also is our reason for giving such facts as we can here, even though they are commonly considered as coming only within the province of the mechanical department.

In order to reduce the cutting time to a minimum it is necessary to maintain as high a cutting speed as possible without injury to the work or to the tool, so the nature of the work must be taken into account. If the piece is small or sets low on the platen the speeds of both cut and return may be greater than if the piece is heavy or sets high above the platen. The weight of the platen itself must also be taken into account.

The reason a direct coupled reversing drive is so effective is that there is no power wasted in intermediate belts, pulleys or shafts and there is no slippage. Since the power necessary to operate a planer or any other tool is the sum of the power required to do the work and the power used to overcome the friction and other losses in the driving mechanism, it is evident that, for a given job, a comparison of the no-load powers will show the difference between any two systems of drives. We find by a large number of comparisons that the saving made by using direct coupled motors averages over 40 per cent. With a direct coupled motor using dynamic braking, the most common method, the current used on reversals is less than with the shifting belt method because enough must be taken from the line, in the later case, to stop the planer in addition to that required to start it and run it. With dynamic braking it is only necessary to use energy enough to start and run the planer, the energy developed in stopping the planer being absorbed in the motor armature and the resistances.

The cost of maintenance, where belts are used, must include the labor and material for repairing and replacing belts; labor and material for pulley, countershaft and bearing repairs; value of time lost while making repairs, if any; cost of general maintenance, oiling bearings, tightening belts, etc., and maintenance of motor and its controlling apparatus. When direct coupled reversing motors are used the only item to consider is motor and control maintenance.

No accurate general figures could be obtained as to the time lost in production due to the use of belts, because the labor necessary to repair and replace belts varies so in different shops, but we know the productiveness of the tools is increased when reversing motors are applied because there is no belt slippage; no flywheel effect or inertia of pulleys to overcome; the cutting speed is adjustable to suit materials and cuts; the return speed can be adjusted to suit the work; no belts or countershafts are to be repaired, and a large amount of time is saved when setting up the work because the platen may be moved any required amount at will.

We have also found that where direct coupled automatic reversing variable speed motors have been installed on planers formerly equipped with belt drive the increased production averages 33 per cent. This means that if a shop has three planers and is so busy as to require a fourth one, the floor space and operating expense of the fourth can be saved by equipping the three existing ones with automatic re-

versing motors and controllers. The cost of three such equipments of medium or large size, for corresponding planers, will be about one-half that of the fourth planer, thus adding to the sum saved by the change..

The various makers have worked out variations in the details of their equipments, but all follow the same fundamentals; that is, the motor must accelerate, stop and start in the reverse direction, and the speed must be adjustable. The planer must also be protected in case of trouble on the power circuit, for if the voltage should go off while the machine is running the platen might run off the bed unless the motor stopped and held it. The essential parts of all control systems are three in number: a contactor panel, a master switch and a resistance.

In view of the enormous number of pulleys, belts, clutches, hangers and other parts which may be eliminated, and the great increase in production and the reduction of power and maintenance charges, your committee recommends that our members advocate the use of automatic reversing direct coupled motors for all machine tools to which they are applicable.

Automatic Control.

This Association has spent a great amount of time discussing motor drives, both as a whole and as individuals, but very little has been said so far regarding motor control. And yet these two go hand in hand, with the control leading the motors. If it is true that one of the most important advantages of motor drive is increased output, it is equally true that motor control is also important for it is only through proper control that increased output can be had. So long as a motor is no more than a driving element it is but very little better than a belt from a line shaft, but when that motor is made to vary in its action as required it then becomes a really valuable adjunct to any machine tool.

Your committee, in taking up the investigation of this part of its report, began at the beginning by considering first the function of machine tools. Then we took up the question of how to accomplish the desired ends, because it is that portion of this problem which interests this organization the most. We are the people who have to struggle with the electrical portions of shop equipment, and it is to us the mechanical department looks for help in times of trouble.

Nearly all of the power consuming work done in machine shops consists in removing metals in the form of chips. That is, the output of any machine is generally measured in terms of the amount of metal it can remove in a given time. Hence, anything which will help a machine remove more metal in a day is a decided and very valuable improvement. It has been estimated that an increase of but 5 per cent in the output of the average machine tool will increase the earnings enough to pay back the cost of applying motor drive and control inside of two years. When the control of that machine is made as nearly automatic as possible, the gain is still greater.

A machine gives maximum output when worked at the highest economical speed and when operated on productive work the maximum amount of the time. Plenty of power must be supplied to and at the cutting tool and the speed must be variable over a wide range if the machine is to work at its highest economical speed at all times. Proper control and large motors are necessary to this end, and we find that a large number of railroad shops have been equipped in first-class manner along both of these lines. In fact, we feel that it is along the line of adopting automatic control for machine tool motors that a very large part of the advance in shop practice will proceed.

Shunt wound, adjustable speed direct current motors, or alternating current motors of essentially those characteristics, are used for most machine tools, but they require suitable controlling apparatus before they are really satisfactory. Automatic control of a motor provides the limiting of the starting, stopping or reversing current to a predetermined value; starts, stops or reverses the motor in the proper amount of time; protects the motor from ground, short circuits and commutator troubles, and limits the torque in the motor and in the machine it drives.

Automatic control not only relieves the operator from the physical acts of starting, stopping and reversing his motor, but also relieves him from the mental exertion necessary to the proper regulation of a motor by a hand controller. He will seldom turn the handle at just the right speed, whereas the automatic controller gives him the fastest safe control and leaves him entirely free in mind and body for his part of the work. This not only makes the employment of a cheaper grade of labor possible, but all of the operations of control will be done in exactly the same way and in the same time, no matter how often they may be repeated after being determined.

In general, any system of automatic control, to be satisfactory, should provide for the following:

First—the motor must start from rest and attain the speed corresponding to the setting of the field rheostat in the shortest safe time and with the current held within safe limits.

Second—the motor must be reversed in the same manner and with the same automatic protection.

Third—the motor should be stopped by dynamic braking or any other similar and suitable method. Preferably this should be accomplished by push button control when required.

Automatic control has been satisfactorily applied to machines with heavy inertia loads, such as punch presses, shears, bulldozers, forging and upsetting machines and others with heavy fly-wheels for both starting and stopping them. In place of clutches for connecting and disconnecting the motor and machine, the automatic controller allows of starting the motor quickly and safely and stops it by means of dynamic braking in the minimum of time. This type of control has also been applied to shapers, slotters and planers to good advantage.

One of the most important applications of automatic control in railroad shops has been to lathes and boring mills, as it allows the start, stop and reverse to be done from any desired point, and an electric brake may be used for quick stopping; friction drives may be replaced by positive drives; quick stops may be made for measuring and a large amount of time saved; the motor can be made to start only on the slow speed and then to quickly accelerate to the proper cutting speed, as predetermined; the motor can be made to automatically drop back to a safe current value in case of overload, and then come back automatically to the proper cutting speed after the overload has passed, and the operator can start and stop without disturbing controller.

The tendency in railroad shops is to demand automatic controlling by careless operators and which will insure the doing of certain things in a certain time. Increased applications of motors demand the development of new controlling devices, and, conversely, the new controllers open up new fields of application for motors. This will result in taking the responsibility from the operator and placing it upon the electrician who installs the equipment and takes care of it, and right there is where the members of this association come into intimate contact with this problem.

An automatic controller is not so simple as a hand operated device for the same service, and it is not always easy to take hold of one and install and operate it, but it must be done by all of us at some time so let us find out all we can about the present state of the art before it is too late. It is evidently impossible for this report to include a description of the various types in use, but the manufacturers will gladly tell you anything you may want to know about their products. Most automatic control devices consist simply of combinations of relays and contactors, so it should not be hard for all of you to learn the underlying principles of any system of control and to take care of it easily.

In view of the very evident advantages of automatic control for machine tools, the great savings to be realized through its adoption and the comparatively low cost of installation and maintenance, your committee recommends that each of you urge its adoption in your shops whenever you have the opportunity or authority to do so. We would also urge you to give the rest of us the benefit of such experiences as you may have already had with automatic control.

Motor Economy and Standardization.

This section of our report deals with problems formerly left to the men in charge of the machine-tool equipment of railroad shops, rather than to the electricians, but with the expansion of the duties of most of our members so they take in the electrical features of the shop equipment, as well as of the rolling stock, these matters take on a new and greater importance. Previous reports have been made on the electrical equipment of railroad shops, to be sure, but this one will consider a different phase of the problem.

It is known to all of you that in every shop there are two distinct service conditions, calling for different types of motors, different methods of control and different methods of applying the motors to the machine tools. That is; there are certain types of tools requiring motors of the constant speed type, and others whose cycle of duties demand an adjustable speed type of motor (wrongly called variable speed motors), those whose speed can be varied to suit con-

ditions, but when fixed remains constant under varying loads.

Alternating current motors are essentially constant-speed machines, and because of their comparative simplicity several railroads have adopted them almost exclusively for their constant speed work in wood working shops, driving pumps and fans, line shafting for groups of small tools and for certain large tools requiring constant speed. On the other hand, no commercial method has as yet been devised for varying the speed of an alternating current motor so it may be used successfully and satisfactorily for machine tool service.

On the other hand, where direct current is available, motors suitable for both constant speed and for adjustable speed are available by the use of direct or continuous current motors. And since it is now possible to get motors with speed variations of as great as 30 to 1 these motors should not be overlooked.

While it is true that the lack of a proper understanding of the joint problems of the motor and tool builder has been a great drawback, thus showing the necessity for some standardization of speed-ratios, control and dimensions, there is also a lack of standardization of the method of supplying the power in machine shops. At present there are about fifteen possible systems available, all of which are in use in various shops and several of them at once in some shops. For instance, we have direct current at 110, 220 and 500 volts and alternating current at 110, 220, 440 and 550 volts and in single, two and three phases at frequencies of 25 or 60 cycles.

So long as this is the case it will be hard to do much in the way of standardization of shop equipments, and your committee feels that something should be done toward the adoption of certain standard power equipments for use in railroad shops. This is a large problem, of course, but there is nothing we could do to justify our existence any better than to attack and solve it. We are doing and have done considerable to standardize car equipments and can do much here if we but make up our minds to it.

The present tendency among railroads is to install turbine driven alternating current generators in their power plants, using this current for lighting, turn-table drive, wood working machines, constant speed motors, etc., and installing motor-generator sets to supply direct current for cranes, variable speed machine tools, etc. This is good practice, so far as it goes, but it frequently goes too far and we find that motors of nearly every possible kind are used in some shops, and that is demoralizing, to put it mildly. If we would profit by the experience of the central stations, whose conditions are similar to ours, a long step in the direction of standardization could be taken very quickly and easily.

When a machine shop is driven through a line-shaft it is not easy to determine the amount of time each machine is in operation, but when electric motors are used (especially as individual drives) it becomes easy to determine both the load factor and the load, and thus the motor economy. And one of the first things noticed after the adoption of individual drives was the fact that the total horse power capacity of the motors in a given shop was always in excess of the generator capacity. A small difference must be expected, but frequently the ratio is as great as 6 to 1, showing that the average time-load factor of the majority of machine tools is comparatively low.

Analyzing this from the standpoints of time of loading, cutting, unloading and idle time shows that it is very seldom necessary to use motors of very high continuous ratings. In fact, for use in railway shops, motors with an intermittent rating based on much less than two hours continuous service have been found entirely satisfactory. This means that motors of much smaller size than formerly used are being installed with a consequent reduction in costs of equipment. This also has a direct bearing on the cost of doing work, through its effect on fixed charges, but we will not go into that here. Nor shall we devote attention to the various other conditions effecting the operation of machine tools further than to say they must be taken into account when choosing motors.

The great point we wish to make is as to the relative economy of the individual motor drive as opposed to line shaft drive, and this may be summarized as follows: Less power required; more speeds possible; time saved in speed adjustments; time saved in reversing; time saved in setting up; time saved by getting proper speed for cutting; time saved by taking heavier cuts; less liability of accidents; more compact arrangement possible and increased economy of operation.

Recommendations.

In conclusion, your committee for this year recommends that our members advocate the use of electric arc welding apparatus for repair and new work in our shops; automatic reversing motors for all machine tools to which they are applicable; automatic control for all machine tools with individual motors; the greater adoption of electric motors generally throughout our shops, and an active attempt at standardization of power supply.

We further recommend that your committee on Data and Information be instructed to gather as many facts as possible during the coming year along the lines of this report in order that they may be available for our members.

Respectfully submitted,

Geo. W. Cravens, *Chairman.*	L. L. Parker,
A. J. Collett,	J. P. Puette,
G. M. Crownover,	C. H. Quinn,
R. E. S. Geare,	E. J. Sergel,
L. C. Hensel,	J. A. Shaw,
E. A. Humphrey,	Chas. R. Sugg,
A. W. Martin,	C. M. Tobias,
W. O. Moody,	H. M. Warren.

The New E. S. B. Axle Lighting System

J. Lester Woodridge

During the convention of the Association of Railway Electrical Engineers, the Electric Storage Battery Co. gave a dinner to prominent railroad officials for the purpose of introducing the E. S. B. axle lighting device, a large number of railroad men being present.

Mr. J. Lester Woodbridge, the chief engineer of the Electric Storage Battery Company, who has developed this device to its present state of efficiency, made the following remarks:

"The axle lighting system recently put on the market by the Electric Storage Battery Company is the result of several years of study, investigation and development and was originally undertaken as a measure of self-defense.

"The conditions under which the storage battery was called upon to operate in train lighting service and especially in axle lighting service were so unsatisfactory from the battery standpoint that they threatened to give the storage battery a most unsavory reputation, which it in no way deserved.

The original axle lighting systems started with the dynamo and regulating apparatus and were designed and developed by dynamo and apparatus designers, who were but little familiar with the storage battery requirements. The storage battery was included reluctantly as a necessary evil and incidentally was utilized as a reservoir to receive all excess current that was not required by the lamps and also to furnish a means for controlling voltage of the dynamo.

"We have taken hold of this proposition from an entirely different standpoint. We have taken the battery as a starting point and have designed the balance of the equipment with reference to the battery characteristics and requirements. This is quite natural, in view of the fact that we are primarily storage battery manufacturers, but it is also quite logical.

"A straight storage battery system has always been the ideal system for train lighting under certain limited conditions, but it is subjected by two very serious handicaps:

"*First.* The limited capacity which it is practicable to install, prevents this straight storage system from being employed successfully on long distance runs.

"*Second.* The battery must be charged at the terminals, either while the car is idle, or by removing the empty battery, and substituting a full one. In addition to these handicaps the straight storage system calls upon the battery for a much greater amount of actual and

necessary work than a properly designed axle lighting system.

"The straight storage system, however, does eliminate a certain amount of the abuse to which axle lighting batteries were formerly subjected.

"The Electric Storage Battery Company's axle lighting system is designed to retain all of the advantages of the straight storage system while eliminating the disadvantages above enumerated.

"In this axle lighting system two new principles have been introduced:

"*First.* The dynamo controls the voltage on the circuit and therefore controls the voltage maintained at the battery terminals, instead of the battery controlling the voltage of the dynamo.

"*Second.* The dynamo is designed for constant voltage rather than constant current; this constant voltage being adjusted slightly above the normal floating point of the battery at a value just sufficient to keep the battery always practically full.

"Before taking up the details of the apparatus I wish to say a few words in regard to constant low voltage charging.

"When we first undertook the development of an axle lighting system, the constant voltage method appealed to us as producing certain advantageous conditions of operation which could not be obtained in any other way. The more we investigated this subject the more thoroughly convinced we were that it was the only correct method of control for an axle lighting system, and we finally decided to adopt it as the salient feature of our equipment.

"It has frequently been asserted that it is impossible to fully charge the battery, or to keep it fully charged at the voltage which we have adopted; that is, approximately 2.25 volts per cell. The most obvious way to answer these statements is to refer to actual facts and the records of the performance of our equipment for the past year which I have briefly summarized on the printed leaflet which we have been distributing at this convention should satisfy anyone on this point.

"During this entire year the battery in question has not been subjected to any gassing charge, nor any charge in fact, except that which it normally receives en route from the dynamo and that without any change in the adjustment of the dynamo voltage.

"These results from the performance of the equipment in service are further confirmed by numerous and extended laboratory tests in which a considerably lower voltage was found sufficient not only to keep the battery charged, but to recharge it after a complete, or partial discharge.

"While the logical facts appeal to most people, there are others who prefer abstract argument. For the benefit of those I would add a few words on this same question from a technical standpoint.

"It is admitted by those familiar with electro-chemistry that the phenomena which take place in the storage battery are completely reversible. Not only are the chemical changes which take place during discharge reversed on charge, so that the active material is restored to its original composition, but the energy absorbed during charge is liberated again during discharge. Thus theoretically we should have 100 per cent efficiency. Practically we cannot attain this ideal result, but there is nothing in the theory of the reactions in the cell which prevents closer and closer approximation to this ideal efficiency with improvement in design and in the selection of materials. Practically there are certain losses which cannot be wholly eliminated, but may be reduced to a minimum by approximating ideal conditions.

"As an illustration of this point I would mention that there are batteries which have been in operation for long periods of time in signal service which are charged from gravity cells at a voltage between 2.05 and 2.1 per cell, the latter maximum never having been exceeded. The voltage on discharge at low rate is over 2 volts per cell, so that the voltage efficiency is well above 95 per cent. It is evident as we approach 100 per cent efficiency in the operation of a storage battery the difference in voltage between charge and discharge must become less and less and finally become negligible. We believe we have demonstrated the fact that in axle lighting service this difference in voltage can, in actual practice, be so far reduced as to eliminate the necessity for any lamp regulator without impairing the satisfactory character of the illumination and without excessive cost of lamp renewals. For an equipment of 16 cells of lead battery we find that a voltage between 35 and 36 volts maintained across the battery terminals when the dynamo is in operation is sufficient to keep the battery full and to recharge rapidly after any extensive discharge.

"A discussion of this question may be taken up from two different standpoints, namely; character of illumination and cost of lamp renewals. In regard to the first it may be said that so long as the changes in voltage are gradual a very considerable range in the intensity of illumination may be permitted without producing unsatisfactory results. In fact the variation in illumination resulting from gradual change from 35 volts down to 32 volts is far less than the difference in illumination at different points in the car, or the changes which take place in ordinary day light illumination. It is true that a rapid fluctuation of voltage of a very small amount will prove very unsatisfactory, but an examination of the method of operation of our apparatus will show that the possibility of any such rapid fluctuations and flickering is entirely eliminated.

"From the standpoint of cost of lamp renewals it may be said that so far we have very little accurate data, owing to the fact that all of the lamp replacements which have been made since the equipment went into service were required either to replace missing lamps, or to renew those which had given out from mechanical causes, such as defective bases; these renewals being made before it was required to renew them on account of blackening or ruptured filament. Thirty-two-volt lamps have been used with this equipment thus far, but if the cost of lamp renewals should be considered somewhat high, on account of the over-voltage there is no reason why 34-volt lamps should not be substituted and we believe the illumination with the latter would be quite as satisfactory as it is with 32-volt lamps in connection with a lamp regulator, inasmuch as the lamps in our equipment are connected directly to the battery terminals without the intervention of any regulating coils, contacts, or artificial resistances.

"Coming now to the details of the apparatus I will add only a few words, preferring you should see the apparatus itself in our exhibit.

"The dynamo is of the so-called Rosenberg type, invented by Emil Rosenberg of Germany and used quite extensively abroad as a constant current self-regulating machine. One of the most important features of this machine is the fact that it develops the same polarity with either direction of rotation, thus eliminating the necessity of any pole changing device. Another important characteristic is the very small amount of energy required for exciting the primary field. This makes the machine especially adapted for the regulator which we have adopted, whose output is comparatively small. In the Rosenberg dynamo the primary field is not used

directly to develop the machine voltage, but merely provides sufficient excitation to send current through a pair of short-circuited brushes; this current by reason of the high armature reaction thereby developed excites the heavy pole shoes, producing the main field which develops the voltage at the load brushes of the machine. The armature and commutator of this machine are, however, no different from those of an ordinary bipolar machine. The only noticeable difference is the presence of the extra pair of short circuited brushes and the peculiar shape of the pole shoes.

"The control consists of a Wheatstone bridge connected across the terminals of the dynamo and comprising resistance of a special characteristic which produces the constant voltage control; these resistances are connected permanently in circuit and the control is affected by their inherent characteristics; there being no moving parts or contacts, no carbon piles, nor solenoids and no adjustments whatever.

"We have provided a means for raising the voltage of the dynamo for a high voltage over-charge when the lamp switch is open, but thus far we have had no occasion to use this modification and, in fact, it was not included in the equipment which has been in service for the past year. We do not believe it will be required but have added it merely as a matter of precaution.

"In addition to the controlling resistances we have an automatic switch which involves some special features. In addition to the usual shunt and series coils, a third coil is added, which is connected between the dynamo and the battery. The main shunt coil is insufficient to close switch, or keep it closed without the assistance of this auxiliary coil, or of the series coil. The auxiliary coil, therefore, determines the closing of the switch by the difference between the dynamo and battery voltage, whereas the switch will open as soon as the current in the series coil drops to O. On account of the latter characteristic the switch is never obliged to break any appreciable amount of current, and no flickering can occur.

"In addition it has been our aim to reduce this equipment to the utmost possible simplicity and to eliminate all adjustments. It is found the constant voltage system of charging automatically takes care of all differences in operating conditions, so that no change in adjustment is required to provide for differences between daylight and night runs, or between summer and winter seasons.

"I desire particularly to call attention to the record of performance of this equipment as set forth on the printed leaflet, which we are distributing, giving a few facts in regard to the results obtained during the past year, including the mileage of over 160,000 miles without a failure.

"Our general policy is to leave no stone unturned to produce an apparatus which shall be first class in every respect, both as to material and workmanship and we are putting it on the market on its merits.

"Assuming the cost of an axle lighting equipment, including battery, at say $1,000 per car in round numbers, the interest amounts to $5.00 per month. This is a small part of the monthly cost of maintenance operation and fixed charges which have in the past been charged against the axle equipment. The first cost, is therefore, a very small consideration in deciding on the best equipment to adopt and while we do not expect our apparatus to be the cheapest on the market from a standpoint of investment, we do believe that in total annual cost it will be far less than anything which has thus far been brought out."

Manufacturers' Exhibits

at the A. R. E. E. Convention

The Adams & Westlake Company exhibited a panel designed to represent the side wall and ceiling of a car, upon which were mounted various car lighting fixtures manufactured by that company. Among these were a new design of a pedestal fixture for coaches, a new holder for metal reflectors in baggage and postal cars consisting of a beaded cast iron canopy with set screw clamp. They also showed a complete line of new "Unity" fixtures described in our October issue, in both the cast iron and aluminum types. Their new "Flex" shade holder was also shown. Their new car lighting and generator with a redesign of the Newbold regulator for car lighting were on exhibit. The company was represented by Mr. G. L. Walters, Mr. R. M. Neubold, Mr. W. S. Ham, Mr. G. E. Ditzler, Mr. J. M. Mercer, and Mr. J. F. Stender.

Exhibit of The Adams & Westlake Co.

American Pulley Company, exhibited their pressed steel car lighting axle pulleys in both the flanged and flangeless types. Also their pressed steel bushing and cast iron bushings for mounting the pulley on the axle. They also showed a line of pressed steel car wheels for motor cars and hand cars. The company was represented by Mr. Morris Rudderow and John Forrest.

The exhibit of the *Central Electric Company,* Chicago, was especially interesting and instructive, they having on display specially constructed wires and cables for railroad work, such as train connectors, battery connectors, charging cables, and motor leads. These were all insulated with the well known and lasting Okonite insulation. Other standard types of Okonite insulated wires and cables, as well as Manson and Okonite tapes were to be seen on the Okonite table.

Diehl car fans were shown in operation, and consisted of the popular standard 12-in. bracket fan with the square base; the sturdy kitchen exhaust fans, both vertical and horizontal, and the Sirocco dining car ventilating system, as well as the English coach fan designed especially for compartments.

D. & W. fuses were well represented; telephone, electric light as well as high tension fuses being shown. A large number of samples of Deltabeston wire and Delta tape, which have reduced the cost of maintenance of headlight generators to a minimum, were distributed to those interested.

The Alexalite Ideal System of Lighting, in both car and office types, were shown. A section of the new Central Electric Company system of car lighting was also exhibited. This system, it is thought, will revolutionize car lighting. The first installation is applied in five dining cars for the C., B. & Q. R. R., which are described in another section of this issue.

A full line of heavy duty Ralco receptacles and plugs were shown, the No. 1 being particularly adapted for portable lamps in roundhouses and machine shops; the No. 2, 30 ampere, the No. 3, 60 ampere, fused, for portable motor work, and the No. 8, 30 ampere and No. 9, 60 ampere, unfused, for portable motor work; the No. 7 for concrete construction, pit work in roundhouses and the No. 5 and No. 6, distributing centers for shop work, and the No. 4 for three phase portable motor work.

Other standard material, such as Anderson charging plugs, Gibbs train connectors, Central Electric gang switches for car use, Crouse-Hinds roundhouse reflectors, etc., were shown.

Central Electric Co. Exhibit

The Central Electric Company especially request railroad men in charge of electrical work who are not provided with catalogues or printed matter to ask for them.

The company was represented at the convention by Messrs. J. M. Lorenz, D. Woodhead, R. N. Baker, F. J. White, J. D. Underhill, J. A. Larson.

Hess-Bright Manufacturing Company exhibited an assortment of various sizes of ball bearings, from 100 lbs. to 15,000 lbs. capacity. They also had an elaborate display of steel balls varying in size from 1/16-in. in diameter to 4-in., weighing from a few grains to 10 lbs. each. They also showed a standard car lighting generator bearing No. 412, and an interesting display of pieces of balls broken in a testing machine, which clearly showed the remarkable structure of the steel from which the balls and races of this bearing are made. Mr. W. L. Batt represented the company at the convention.

Kerite Insulated Wire & Cable Company exhibited numerous samples of wire with Kerite insulation specially constructed for railroad use. They also showed a section of an interesting cable which had been in use since 1886 on the 3rd avenue "L," New York City, and are still in service. The company was represented at the convention by Messrs. B. L. Winchell, Jr., Maj. Azel Ames, G. A. Fraber and J. W. Young.

National X-Ray Reflector Company exhibited both indirect and direct lighting units. The latter are finding a wide application at the present time in railroad machine shops, etc., where efficiency is an important factor. Two of the new Curtis portables attracted a great deal of attention, particularly on ladies' night.

A new unit for indirect lighting in passenger cars was also exhibited. A special reflector holder has been de-

National X-Ray Reflector Co. Booth

signed for this unit, which is of very sturdy construction and holds the reflector firmly in position. Messrs. H. B. Wheeler and H. P. Kean, represented the company at the convention.

Gould Coupler Company, exhibited their Gould Simplex system of electric car lighting with a motor generator set operating at all the various speed ranges, from zero to 90 miles per hour. The new ball bearing generator was exhibited with the covers removed to show brush rig and bearings. A model of the pole changing device which could be turned with a hand lever, was also shown. Their standard car lighting battery, one cell of which had part of the tray cut away so as to

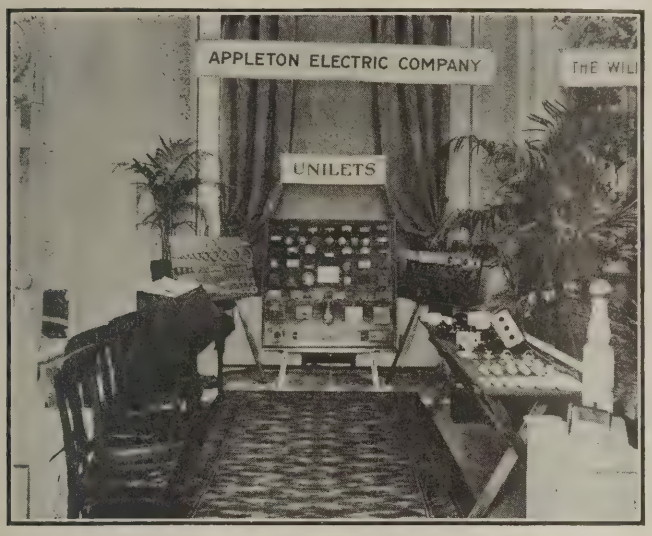
Exhibit Booth of Gould Coupler Co.

show the plate arrangement, was exhibited. The company was represented by Messrs. Geo. G. Milne, R. C. Hull, Dr. C. W. Gould, Col. Jno. T. Dickinson and Geo. R. Berger.

National Metal Molding Company exhibited a complete line of sherardized conduit and fittings for car and ge-

eral wiring. The company was represented by I. A. Bennett, H. C. Moran.

Appleton Electric Company, exhibited their improved line of stamped steel "Unilets" for ½ in. to 3 in. conduit. A new vapor proof lamp guard unilet for use in round houses, foundries, etc., was shown. Numerous gang switches and pulley boxes of all sizes were also



Appleton Electric Co. Booth

shown. The company was represented by Mr. R. P. Tillotson and Mr. C. A. Bloom.

National Lamp Works of the General Electric Company exhibited various types of incandescent lamps varying in size from 10 watts to 500 watts of the regular mazda types, and a 750 watt, 1,500 candlepower, 110 volts, and a 1,000 watt 2,000 candlepower, 220 volt nitrogen filled incandescent lamp. This is practically the first time these new lamps had been exhibited and they attracted a great deal of attention. This filament is in the form of a long coil about 1/16 in. in diameter, which is carried by supports something the same as the filament of the present mazda lamps. A complete line of miniature lamps were also exhibited. Messrs. C. W. Bender and J. A. Hamilton represented the company at the convention.

Exhibit of National Lamp Works of General Electric Co.

The Crouse-Hinds Company had a most interesting and instructive exhibit of their many railway specialties, which included a new 3 phase portable motor plug and receptacle, a new charging plug and receptacle, which will interchange with the Anderson type, designed for both the underground and surface conduit runs, a complete line of condulet fittings and panelboards, the latter

General View of Crouse-Hinds Co. Booth

being specially designed for car lighting. They also exhibited a large panelboard upon which were mounted the conduit fittings for a complete "pull in" system for a passenger car from the generator connector, which receives the cables from the generator, through the various junction boxes to battery fuse boxes, charging plugs and to distribution panel, thence to the various lamp circuits.

An advance bulletin on new railroad fittings, which was printed specially for this convention, was distributed to those interested.

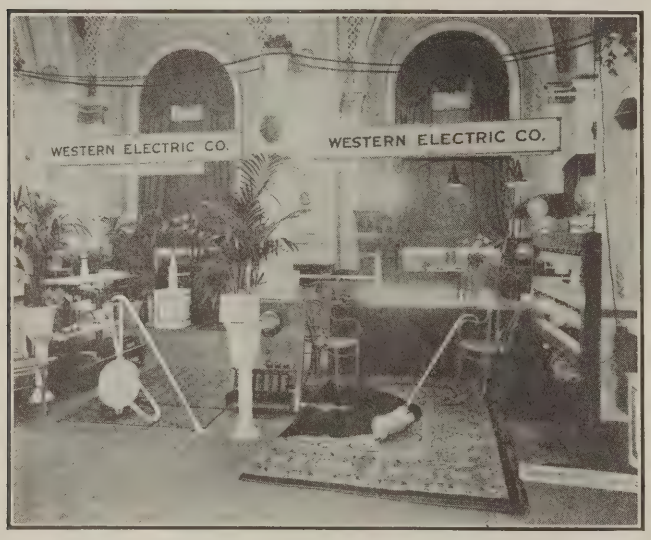
They also exhibited a new type of fitting for cars consisting of an aluminumized steel reflector with globe

Closer View of Crouse-Hinds Co. Exhibit
Showing Car Interior Conduit Construction and Lighting Fixtures

and guard; also a new design of condulet for subway work, and a line of composition covers for condulets to replace the porcelain covers previously used in wiring cars, cranes, etc., where serious vibration is encountered. A new line of enamel steel reflectors with vapor proof globe protecting condulets for use in round houses, etc., were exhibited, together with a 20 ampere polarity plug and Hubbel receptacle. They also exhibited a line of condulets complete with night switch, with gasket cover, arranged so as to be water tight for exposed places or in sub-marine work. A new heater unit con-

dulet with switch attachment, plug, and pilot lamp for electric cooking and other heating apparatus was on exhibit together with a complete line of gang switch boxes of both the push button and snap type. The company was represented by A. F. Hills, F. F. Skeel, F. M. Hawkins, W. M. Fagan, C. M. Crawfoot, E. G. Smith, Chas. Dubsky, M. J. Keifer.

Western Electric Company occupied a double booth in the center section of the South Room and exhibited some of the many lines handled by that company; vacuum cleaners, for car and office use, Habirshaw wires and cables, Western Electric railroad shop interphones, Sun-



View of Western Electric Co. Booth

beam Mazda lamps for train lighting and general railroad use. D. & W. specialties, Patterson wireless battery holders and Fairaday signal bells. They also exhibited a novel electric hand lantern which carried a small battery and tungsten lamp. Messrs. Geo. H. Porter, P. W. Green represented the company at the convention.

Electric Storage Battery Company exhibited their new car lighting equipment which attracted many visitors to this booth. This equipment is described in another part of this issue. The company was represented at the convention by Mr. J. Lester Woodbridge, Mr. G. H. Atkin, Mr. H. E. Hunt, Mr. H. M. Beck, and Mr. R. I. Baird.

Electrical Testing Laboratories exhibited a large number of photographs showing the methods and facilities for testing lamps and other electrical equipment in their New York laboratories. Mr. Norma D. McConald and Mr. Preston S. Millar, represented the company at the convention.

General Electric Company occupied a large space in the south exhibit room and showed many devices, including transformers, motor accessories, steam flow meters, cloth pinions, crane controllers, automatic controllers, sockets and wiring material, Sprague Works Greenfield conduit, heating devices, arresters, etc. They also exhibited a new locomotive storage battery head light equipment employing a 6 volt, 60 watt lamp of the new nitrogen gas type, which delivered over 100 candlepower, the filament construction of this lamp being wound in a concentric double helix, that is, one coil inside the other, concentrating the total light flux almost in a point so that with the 20-in. reflector of 2¾-in. focus, a powerful beam of light is projected down the track. It was stated that with this light a man in dark clothes against a green background was picked up at 1,200 ft. A new turbo-generator, steam driven unit for providing current to both head lamp, cab and marker lines is under construction.

One of the new nitrogen lamps was exhibited delivering approximately 1,700 candlepower at 1,000 watts consumption. The extreme brilliancy of this light was such, however, that it was not turned on except by special request. The company was represented by Mr. J. Scribner, Mr. B. F. Bilsland, Mr. L. C. Porter, Mr. S. W. McCune, and Mr. J. L. Parker.

George Cutter Company showed numerous designs of station platform lighting units, special car lighting panels, and their new "Idealite" line of fixtures. Mr. O. B. Duncan represented the company at the convention.

Cutter Electric & Manufacturing Company exhibited the well known I. T. E. circuit breakers illustrating some of the special designs for use in railroad practice. The company was represented at the convention by Mr. H. F. Darby and Mr. C. E. Wise.

Economy Fuse & Manufacturing Company exhibited a complete line of renewable fuses from 1 to 600 amperes, 600 volts, also some 2,500 volt fuses. A laboratory standard instrument and resistance for testing fuses was available and some survivors of the Ohio floods in the shape of Economy fuses, looking pretty muddy but still entirely serviceable, were shown. Mr. E. L. Eustice, Mr. J. B. Griffiths, and Mr. A. E. Trigenza, represented the company at the convention.

The booth of the *Safety Car Heating & Lighting Company* was one of the most attractive at the convention. Four large white Corinthian pillars supported a large panel with decorative frieze above. Upon this panel were installed some of the more recent types of fixtures designed by this company, including the reflector envelope unit, a semi-indirect unit, and a totally indirect unit with an illuminated art glass bowl below, the

Exhibit of Safety Car Heating & Lighting Co.

White Iris and the Pyro reflectors designed specially for car lighting. In addition to the center deck unit, were numerous side deck units and birth lamps.

These fixtures were all illuminated by an operating car lighting equipment. A motor generator, the generator of which was a standard type D safety generator, was driven at variable speeds by means of an automatic controller varying the speed from zero up to the equivalent of 90 miles per hour. The standard regulating and switch panels were shown and in addition to these, there was the small test meter board upon which were shown generator voltage and current, lamp voltage and current and battery current at the various speeds. The

company was represented by Messrs. A. C. Moore, Geo. E. Hulse, J. H. Rodger, C. A. Pinyard, W. H. Marsh, Delos G. Haynes, and Mr. William Reader.

United States Lighting & Heating Company had a running exhibit showing the axle equipment in operation. A motor starting arrangement automatically started the motor-generator set and drove it at all the various speeds from zero to 90 miles per hour with 2 slow downs and a 1½ minute stop at a station, when the cycle was repeated. They exhibited their new type C generator which is 2 in. longer than the type O machine but of the same diameter. The flexible bead insulation for generator leads attracted attention. The new U. S. L. ball bearing mounting was exhibited which permits of the removal and application of the bearing without applying pressure. Generator controlling panel consisted

U. S. Light & Heating Co. Exhibit

of 3 sections, (1) potential regulator and lamp regulator relay, (2) current regulator coil and automatic switch, (3) lamp regulator. On a large display board were mounted parts of the equipment showing detail construction of the bearing lock mounting, dash pots, relays, etc. A type B lamp regulator in steel case for outside mounting was also shown. Messrs. W. P. Hawley, C. C. Bradford, W. F. Bauer, Alex Russell, Dr. J. E. Widner, Bertram Smith, R. E. Stuntz, W. A. Turbayne, W. L. Bliss, L. S. Cunny, R. C. Haley, H. A. Mathews and Geo. Hentges represented the company.

Sangamo Electric Company exhibited 3 panels on each of which was mounted an ampere hour meter operating under load conditions. One of these meters was a simple duplex train type, recording total charge and total discharge. Another was the simple shunt type, recording individual discharge and charge in the reverse direction with totalizing dials for recording total charge. On the third panel one of the new "Resistor" type meters with a special Pennsylvania dial was operating. This meter is arranged so that it automatically runs slower on charge than on discharge by any desired percentage. This will automatically provide proper overcharge of the battery to make up for battery loss, etc. Messrs. R. C. Lanphier and A. E. Pickard, represented the company at the convention.

Benjamin Electric & Manufacturing Company, exhibited their new angle type reflector socket, which has been specially designed for loading and unloading platforms, and other similar service requiring that the light be directed from the side. The new lamp grip feature now placed in all receptacles manufactured by this company, which prevents the lamp from working loose, was shown. A new dust and gas proof globe for roundhouses, foundries, etc., and the new lock steel wire guard, for preventing theft and injury of lamps, was also shown. The company was represented by H. E. Watson, G. B. Weber, and A. E. Lubeck.

The Norma Company of America, exhibited their No. 412 Norma roller bearing designed for the pulley end generator bearing, the rollers of which run on a cylindrical inner race and a curved outer race. The company was represented by Mr. W. M. Nones, G. R. Bott.

Oneida Steel Pulley Company exhibited their Keystone railroad axle pulley in both the flange and flangeless types and also their corrugated bushing for mounting on a tapered axle. Mr. N. G. Stark represented the company at the convention.

Pyle National Electric Head Light Company exhibited their two latest types ES and E electric headlights. These two headlights are an entirely new design and the headlight cases are electrically welded. Models and sectional views of the turbine were also shown. The company was represented by Messrs. J. Will Johnson, R. C. Vilas, Wm. Miller, C. P. McGinnis and J. E. Kilker.

Railway Electrical Engineer occupied commodious but busy quarters at the registration desk. It was represented at the convention by Mr. George W. Cravens and Mr. Edward Wray.

Remy Electric Company exhibited their new model D 30 volt equipment, the armature of which is ring wound and operates at 2,800 r. p. m. and the rotating element is supported by an S. K. F. ball bearing at the armature end and by plain bearing at the turbine end. Messrs. E. W. Roland and J. R. Howe, represented the company at the convention.

Edison Storage Battery Company had a very attractive exhibit in one corner of the Red Room, which was beautifully decorated with palms and ferns and some luxurious easy chairs and sofas to welcome the visitors to this booth. A large panelboard showed the various component parts of the Edison battery at different stages in its manufacture. The company was represented by Mr. H. G. Thompson, Mr. E. M. Cutting, Mr. F. V. McGinnis, and Mr. C. A. Luckey, at the convention.

Westinghouse Lamp Company exhibited a complete line of incandescent lamps for train lighting as well as the larger types for shop and station use. They also exhibited one of the new nitrogen filled mazda lamps of

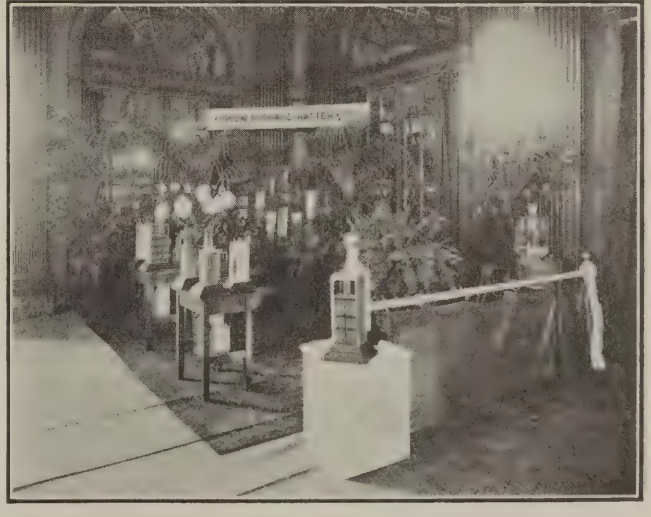


Exhibit of Edison Storage Battery Co.

an efficiency of ½ watt per candle. Messrs. B. F. Fisher, W. H. Rolinson and A. J. Cole represented the company at the convention.

Westinghouse Exhibit.

One of the exhibits which excited much interest was that of the Westinghouse Electric & Manufacturing Company due mainly to the fact that they showed for the first time several new departures in manufacture heretofore unknown to the general public. The new type "CS" steel frame squirrel cage induction motor with its indestructible rotor excited great interest. The new type "C" magnetic control for remote operation of D. C. Motors by push-button control was shown in actual operation in connection with a 10 H. P. steel frame type "SK" interpole direct current motor, the motor which has superseded the type "S" motor so well known to the public. The latest form of wheel lathe control operating a 30 H. P. type "SK" motor was simplicity itself. Facts brought out in the construction with this wheel lathe control pointed to extreme simplicity of construction, and extreme ease in manipulation. This wheel lathe control together with the reversing planer control and other automatic devices manufactured by this Company mark an epoch in the recognition by this manufacturer of the "Safety First" movement In other words all of these controls are operated merely by push-buttons or snap-switches

Westinghouse Electric & Mfg. Co. Exhibit

and all of the working parts of the controls are completely housed so that it is absolutely impossible for the careless workmen to come in contact with any current carrying parts.

Other exhibits by this Company comprised the new flaming arc lamp, the pullman car fan and many smaller devices. A great deal of stress was laid on the rotor construction of the "SC" Motor. They showed the rotor of a 20 H. P. motor separately from the motor itself. It will be noticed from the photograph of the exhibit that this rotor was labeled "The Indestructible Rotor," a fact made possible because of the actual casting of the end rings to the rotor bars and the use of fire, water, and acid proof cement forced in under hydraulic pressure and baked to 400 degrees centigrade as insulating material between the iron and copper in the rotor. Further stress was laid upon the high efficiency of the "CS" motor together with the fact that all slots were open coils form wound, bearings of extra large size, etc., etc.

Among the company's representatives was R. F. Moon of the Philadelphia Office, H. C. Mode, of the Pittsburgh Office, J. H. Bryan from the Company's Works, East Pittsburgh, and R. E. S. Geare in charge of Railroad Sales in Chicago Office.

Willard Storage Battery Company had a beautiful decorated booth supplied with easy chairs which were banked with ferns and palms. By way of diversion from the real business of the convention, they exhibited a car lighting battery with section cut away to show the internal construction. The company was represented by Messrs. W. E. Ballantine, F. S. Gasoway, H. S. Gardner, Lewis Sears and J. T. Foster.

Main Belting Company exhibited numerous samples of their Leviathan belt, including the special car lighting

Main Belting Co. Booth

belt. Mr. W. E. Fawcett represented the company at the convention.

S. K. F. Ball Bearing Company had an operating exhibit showing a bent shaft supported at either end by S. K. F. self aligning bearings. This clearly showed the self aligning feature of the bearing in compensating for shaft deflection, etc. Mr. H. E. Walker represented the company at the convention.

Weston Electrical Instrument Company exhibited their new miniature type instruments which are particularly adapted for railroad use, as well as several standard and laboratory types. Messrs. Batt and Westburg, selling agents of the Weston Company, in Chicago, represented the company at the convention.

In addition to the above the following companies were represented at the convention as indicated below:

Adams, Bagnall Electric Company—B. A. Stowe and C. W. Beach.

Brookfield Glass Co.—Mr. B. F. Webb.

Consolidated Ry. Elec. Lt. & Equip. Co.—Patrick Kennedy, and Thomas L. Mount.

Diehl Manufacturing Company—J. R. Marvin and H. H. Smith.

Flexible Steel Lacing Company—G. E. Purple.

Holophane Works of General Electric Company—L. C. Doane and R. M. Prior.

Independent Lamp & Wire Company—R. S. Carrick.

Oliver Electric & Manufacturing Company—F. W. Oliver, and Charles Gelan.

Pass & Seymour Company—V. R. Despard.

Phillips Manufacturing Company—A. L. Watson and Wm. M. Lalor.

The Pocket List of Railroad Officials—Charles L. Dinsmore.

Wm. C. Robinson & Son Company—C. G. Swank.

Standard Underground Cable Company—R. E. Greene.

Registration of Railroad Men at the Convention

ATCHISON, TOPEKA & SANTA FE R. R.

S. W. Everett, Asst. El. Eng.
H. G. Myers, El. Frm.
Z. Humphrey, Ch. Elect.
A. E. Voigt, Ch. Clerk.
W. C. Burgess, El. Insp.
C. B. Jennings, Elect.

ATLANTIC COAST LINE.

C. R. Sugg, El. Eng.

BOSTON & ALBANY.

C. W. Dodge, Ch. Elec.
Lester B. Knight, Frm. Elec. Car. Dept.
L. W. Hyde, Elect.

BALTIMORE & OHIO R. R.

J. H. Davis, Elec. Eng.
L. S. Billau, Elec. Dept.
J. D. Brown, Ch. Elec.
C. E. Singer, Ch. Elec.
N. G. Wolf, Asst. Ch. Elec.
C. H. Reynolds, Trn. Elec.
H. F. Winters, Regltr. Insp.
J. S. Smith.

BELT RAILWAY OF CHICAGO.

Willard Doud, Shop Eng.

CHICAGO, MILWAUKEE & ST. PAUL RY.

C. R. Gilman, Ch. Elec.
H. J. Frenk, Elec. Frm.
J. Schimm, Main Elec.

CHICAGO & WESTERN ILLINOIS R. R.

R. F. Crain, Elec.
E. R. Duffin, Elec.

CHICAGO, INDIANA & SOUTHERN RY.

N. E. Greenawalt, Ch. Elec.

CHICAGO & EASTERN ILLINOIS R. R.

J. H. Burcham, Ch. Elec.

CHICAGO & COUNTY JUNCTION R. R.

John L. Ohmans, Elec. Frm.
C. J. Peters, Elec.
John A. Perry, Elec.

CHICAGO GREAT WESTERN RY.

Geo. R. Shirk, Ch. Elec.

CINCINNATI, CLEVELAND & ST. LOUIS.

C. M. Tobias, Ch. Elec.
C. A. Franck, Elec. Frm.
J. E. Giunness, Frm.

CANADIAN PACIFIC R. R.

E. S. Mac Nab, Car Lighting Inspector.

CHICAGO & ALTON.

C. L. Abrams, Ch. Elec.
Anton Abramic, Elec. Frm.
W. W. Chance, Elec. Frm.

CHICAGO, BURLINGTON & QUINCY R. R.

J. E. Gardner, Elec. Eng.
Fred McGary, Ch. Elec.

CHICAGO, ROCK ISLAND & PACIFIC R. R.

C. J. Glover, Elec. Eng.
R. W. Pachaly, Frm. Elec.
J. G. Eberler, Ch. Clk. to Elec. Eng.
E. Johnston, Elec. Insp.
H. R. Pennington, Tr. Elec.
Howard W. Gammell, Tr. Elec. Insp.
M. K. Holland, Elec.
J. C. Willms, Elec.
Christ Willms, Elec.
James S. Shutes, Elec.
J. W. North, Elec.
Edward Rubedew, Elec.
William Tibbatts, Elec.
Geo. M. Price, Elec.
M. H. Pursian, Elec.
Harry D. Andrews, Elec.
E. Rubedew, Battery Man.
Edward Dohney.

CHICAGO & NORTHWESTERN RY. CO.

A. J. Farrelly, Elec. Eng.
Joseph A. Andreucetti, Gen. Frm.
Robt. Daniels, Frm.
A. A. Kemp, Elec. Insp.
Geo. E. Murray, Ch. Elec.
A. J. Johnson, Elec.
W. R. Dudley, Elec.
Wm. C. Chapman, Elec.
W. H. Briggs, Train Elec.
Geo. C. Beard, Train Elec.
A. R. Wicklander, Reg. Man.
D. W. Stephens.

CHESAPEAKE & OHIO RY.

F. C. Watson, Ch. Elec.

DETROIT & MACKINAC RY.

Frank Black, Ch. Elec.

DELAWARE, LACKAWANNA & WESTERN RY.

C. D. Axtell, Gen. Frm.

FRISCO LINES.

L. C. Hensel, Ch. Elec.

ILLINOIS CENTRAL R. R.

E. W. Jansen, Elec. Eng.
A. L. Chapin, Asst. Elec. Eng.
L. C. North, Shop Supt.
G. B. Colegrove, Ch. Elec.
J. D. McElree, Ch. Elec.
J. H. Wickman, Gen. Frm.
C. B. Gallagher, Elec. Frm.
J. D. Younger, Elec. Frm.
J. C. McElree, Asst. Ch. Elec.
B. W. Sackett, Elec. Insp.
C. A. Jansen, Elec. Insp.
Leonard J. Altstatt, Elec.
E. P. Blomberg, Elec.
H. Huber, Elec.
Frank Magoriel, Elec.
Harry Aregood, Elec.
J. C. Timewell, Elec.
J. A. Maginel, Elec.
G. G. Harris, Elec.
T. H. Hopkins, Elec.
O. E. Peterson, Elec.
George R. Nelson, Elec.
L. A. Riley, Elec.
J. Homer Brown, Elec.
Karl A. Ranth, Elec.
Fred Kamp, Elec.
Charles Schiedow, Elec.
N. F. Nissen, Elec.
John Lahndoff, Elec.

KANSAS CITY TERMINAL.

S. O. Swenson, Elec. Eng.

LOUISVILLE & NASHVILLE R. R.

Ward Barnum, Elec. Eng.

LEHIGH VALLEY R. R.

D. J. Cartwright, Elec. Eng.
Wilson Crawford, Jr., Car Lighting Frm.

LAKE SHORE & MICHIGAN SOUTHERN RY.

H. C. Meloy, Supv. Elec. Ap.
J. P. Puette, Asst. S. E. A.
I. R. Wentworth, Elec. Frm.
Geo. H. Waichter, Elec.
E. L. Collins, Elec.

MISSOURI PACIFIC R. R.

H. F. Pfeffer, Elec.

MINNEAPOLIS & ST. LOUIS RY.

J. R. Smith.
R. W. Falkenson, Elec.

MICHIGAN CENTRAL R. R.

William F. Lietzan, Elec.

NORTHERN PACIFIC R. R.

W. J. Bohan, Mech. Eng.
S. K. Hare, Ch. Elec.
L. C. Buchholz, Elec.

NEW YORK, NEW HAVEN & HARTFORD R. R.

Frank Zimkowski, Elec. Frm.

NORFOLK & WESTERN RY.

C. H. Quinn, Mech. Eng.

NEW YORK CENTRAL R. R.

William A. Del Mar, Asst. Eng.
Harry W. Smith, Frm. Elec.

GREAT NORTHERN RAILROAD.

E. A. Humphrey, Asst. Elec. Eng.

NEW YORK CENTRAL & HUDSON RIVER RY.

Alex. McGary, Ch. Elec. Car Dept.

PERE MARQUETTE RAILROAD.

Frank J. Hill, Ch. Elec.

PENNSYLVANIA RAILROAD.

J. R. Sloan, Eng. Elec. Car Ltg.
Ed. E. Godard, Asst. Eng. Elec. Car Ltg.
T. V. Buckwalter, Mech. Eng. Dept.
Stephen C. Potts, Asst. Frm. Phys. Lab's.
L. L. Newman, Supt. E. C. L.
J. M. Craig, Sup. Elec. Car Ltg.
D. B. Pastorius, Supt. Elec. Car Ltg.
J. L. Minick, Frm.
C. J. Cansland.
E. W. Breese, Car Ltg. Frm.
W. G. Guffin, Asst. Car Ltg. Frm.
J. C. Snyder, Train Ltg. Insp.
D. G. Thwaites, Train Ltg. Insp.
J. E. Roller, Insp.
Charles L. Dables, Asst. Frm. of Elec.
W. H. Keirn, Frm. Elec.
E. H. Dllo, Elec.
Joseph Wright, Elec. Rep. Man.

PULLMAN CAR COMPANY.

N. E. Lemmon, Ch. Elec.
P. L. Pflager, Asst. Ch. Elec.
George H. Scott, Elec. Insp.
M. B. Osburn, Elec. Insp.
W. M. Wiggins, Insp.
Fredrick W. Weaver, Insp.
C. R. Thompson, Elec. Insp.
J. F. McLaughlin, Elec. Frm.
W. A. MacCollum, Elec. Frm.
Edwin J. Goddis, Fmn. Elec.
G. A. Smith, Elec.
Frank L. Brawn, Elec.
Geo. B. White, Elec.
James Malone, Elec.
Harry B. Feltwell, Car Elec.
R. C. Thomson.

SOUTHERN PACIFIC R. R.

J. J. Hack, Eng. Trn. Lgt.

SUNSET CENTRAL LINE.

S. L. Sikes, Ch. Elec.

ST. LOUIS & SAN FRANCISCO RAILROAD.

O. G. Williams, Trav. Axle Light Insp.
James E. Hilton, Gen. Motor Car Insp.

SEABOARD AIR LINE.

H. M. Gumm, Elec. Eng.

UNION PACIFIC R. R.

A. J. Collett, Elec. Eng.

WASHINGTON TERMINAL.

E. A. Van Bushkirk, Elec. Frm.

WHEELING & LAKE ERIE R. R.

H. W. Leinbach, Elec. Eng.

UNCLASSIFIED.

R. Fancher.
M. R. Garnett.
E. W. Gerdes.
R. E. Kelly, Elec.
Thomas B. Larkin, Elec. Helper.
R. M. Lytle, Elec. Frm.
F. A. Luettich.
William Meehan, Elec.
Arthur Meyer, Bat. Work.
R. F. Shipway, Elec.

Electrification of Railways

PROFESSOR GISBERT KAPP

Editor's Note—At the recent meeting of the British Association for the Advancement of Science, at which Sir Oliver Lodge delivered his already famous address on "Continuity," numerous other addresses were presented by the presidents of the various sections. The address of Professor Gisbert Kapp, president of the engineering section, was devoted very largely to the discussion of the electrification of railways. His address contains much valuable information which will be of special interest to our readers, in fact, it is about the most comprehensive statement of the situation ever made, so instead of abstracting this paper, we are publishing it in almost complete form.

It is just thirty years since the first electric railway was opened for public use. That was a small line in Ireland, known as the Portrush-Bushmills Railway. In those days only the continuous-current motor was available, and that only at a very moderate pressure and power. These restrictions were from the first felt to be a serious drawback, and inventors tried to overcome them in various ways. Of these, two may be here noted, in passing. Ward Leonard in 1891 made the suggestion of carrying on the train a converting station. He argued, quite correctly, that for the transmission of power to long distances the alternating current was eminently suitable, and that, consequently, the power should be sent to the train in the shape of high-pressure alternating current. On the other hand, such a current was, in those days, quite unsuitable for motors; hence the necessity of its conversion into continuous current, with which the then available motors could alone deal. Ward Leonard suggested to put on the first vehicle of the train a synchronous motor, which drives an exciter and continuous-current generator. The current obtained from this generator was to be used to drive the train-motors, which might be distributed in a number of motor coaches. The regulation of speed and tractive force was to be effected entirely by suitable adjustment of excitation, and therefore without rheostatic loss. It will be admitted that this proposal has some attractive features. It is essentially a long-distance system, and at the same time it offers the possibility of great and uniform acceleration, a matter of great importance in urban traffic, so that it is equally suitable for both kinds of service. Moreover, the current can be taken with unity-power factor. Unfortunately the extra weight which has to be carried in the shape of converting machinery is a serious drawback; and for this reason the Ward Leonard system (excellent as it has proved in other applications of electric power) has in the domain of traction never got beyond the experimental stage.

The experiment has been made on a fairly large scale, but with this difference, that the traction-motors were placed not into motor coaches, but on the first vehicle itself, which thus became an electromotive; also, in order to save the weight and cost of starting and synchronising gear, the asynchronous type of single-phase motor was adopted, thus sacrificing the advantage of unity-power factor. The electromotive developed at the hour-rating 200 horsepower, and weighed forty-six tons. This is not a very brilliant achievement, and it was beaten by a sister engine of the same power, but using alternating-current motors. This electromotive weighed only forty tons.

It is probable that a better weight efficiency could be obtained nowadays with this system if carried out on a larger scale, and if the motor-generator were replaced by a converter, in which case the step-down transformer would have tappings on its secondary side for starting and regulation. It is, however, doubtful whether even then it could compete with electromotives using the alternating current in the motors directly. Motors of this type have recently been so much improved that the margin of weight that could be saved by the use of continuous-current motors is probably less than the excess weight of the converting machine.

Direct Current Three Wire System

The other attempt to combine high trolley-voltage with low motor-voltage has shared the same fate. This consisted in the application of the three-wire principle of continuous current supply to electric traction. It is in successful operation at a moderate voltage on a London tube railway, but as far as main-line working is concerned it has not got beyond an application on two small lines in Bohemia. The principle adopted is to make the trolley wire of the up-line the positive and that of the down-line the negative side of the system, whilst the rails take the place of the zero wire. Each electromotive is fitted with four motors, of which at least two are in series, taking 1,500 volts. Thus, whilst the voltage of one motor is kept within the customary limit of 750 volts, the pressure of the whole system is 3,000 volts. The objection to this arrangement is that its fundamental supposition of a fairly close balance between the two halves of the three-wire system must in actual railway working be rather the exception than the rule, and that the obvious remedy of combining both halves of the system in one and the same train would involve the use of two overhead trolley wires, and thus introduce the very feature which the advocates of the continuous-current system find so objectionable in three-phase traction. Moreover, the recent improvements made in continuous-current motors has reduced the importance of the three-wire principle. Continental makers are prepared to build motors for 1,200 volts, and one English maker is actually building motors for 1,750 volts, so that with two motors in series a trolley-pressure of 2,400 and 3,500 volts respectively can be used.

Single Phase System

The present tendency in electric traction is in the direction of simplicity, in the sense that mixing up of different types of current and dependence of one train on another is avoided. Only three types of current are used—namely, continuous, three-phase, and single-phase. The two first-named are used direct; the last through the intervention of a transformer. In a large measure the different systems have already become standardized. As regards the d. c. system, up to 750 volts the process of standardization has been completed long ago. It is almost generally adopted for urban and suburban lines of moderate length, unless there are local difficulties as regards the third rail, or it is desired to work the suburban and the main-line service on the same system. The three-phase system has also been fairly well standardized, but the single-phase system is still in a process of development—a development which, however, takes place on a fairly large scale. In France the Compagnie du Midi is electrifying on the single-phase system nearly 400 miles of track; the German Government have already electrified the Dessau-Bitterfeld of the Leipzig-Magdeburg line, and are electrifying the line Lauban-Koenigszelt in Silesia, to say nothing of some smaller

private lines in the South of Germany, which have been in operation for some years. In Switzerland the Berne-Loetschberg-Simplon Railway, already in operation, and the Rhaetian Alp Railway, nearing completion, also employ single-phase electromotives. Both in France and Germany the type of electromotive to be finally adopted has not yet been settled, but half-a-dozen different types, supplied by as many different makers, are being tried, and it is in this respect that one may look on single-phase traction as still in the process of development. As regards the Loetschberg the period of trial is over. Three years ago the railway company ordered a 2,000 horsepower electromotive, and have had it at work ever since with such satisfactory results that they have decided to adopt this type definitely, and have ordered thirteen more engines, but of the slightly larger power of 2,500 horsepower on the 1½-hour rating. Of these I shall have to say something more presently; but before entering into the details of single-phase traction it is expedient to glance briefly at the present position of the rival system of three-phase traction.

Three Phase System

The first application of this method of working dates back to the end of last century, and took place on a small Swiss line; then followed the well-known Valtellin line, and, later still, when the Italian Government took over the railways, the Government engineers decided to extend the application of three-phase traction to some other lines—a decision which practical experience has shown to have been perfectly justified. The total power represented by three-phase electromotives either at work or on order in Italy today exceeds 200,000 horsepower (95,000 horsepower in service, and 120,000 horsepower building). Ten years ago the three-phase system was the only possible one for main-line working, but later on there came on the scene the single-phase, and, later still, the high-pressure continuous-current systems, and I need hardly mention that between the advocates of the three systems there has been waged a fierce battle, each claiming that his is the best and the others very inferior. I am afraid that battle is still raging; but it is a futile war, for there is no such thing as a best system generally. One system is the best for one set of conditions and another for another set. Thus the German railway engineers found that the single-phase system would serve them best, and they adopted it. There is in this matter no question of personal feeling or national prejudice. I have no intention to enter the lists as an advocate for any one of the three possible systems for main-line traction; each has its special features and special merits, and all I can do is to place before you some of these. As the three-phase system is the oldest, it will be convenient to take it first.

It is curious to note that the three most obvious objections which have been raised against three-phase electromotives by theorists have been found to have but little weight in practical work. These objections were: the complication of a double overhead wire, the danger that the motors would not share the load fairly, and the inability to run without rheostatic waste at intermediate speeds, or to run at a higher than synchronous speed to make up for lost time.

That an overhead wire is inconvenient must be readily admitted, but the inconvenience applies to all methods of main-line working, for the so-called third rail is not applicable to high pressure, and even if it were, the consideration of the safety of the platelayer would preclude its use. The question then is: are two wires twice as objectionable as one? Possibly, but the most objectionable feature is not the wire itself, but the posts or gantries on which it is carried, and the number of posts is the same, whether we use three-phase, single-phase, or continuous current. There is a little more complication at the cross-over points and at the switches; but this is not a serious matter, if one may judge from the perfectly smooth working of so extended a yard as that at Busalla, where there are five miles of track, connected by thirty-seven switches and crossings. The other objection—as to the motors not sharing the load equally—is theoretically sound. The torque developed by the motor is proportional to the slip, and in order that the two motors on an electromotive shall share the load equally their slips, and consequently also their speeds, must be the same. Now, it is conceivable that, owing to a slight difference in the size of the drivers, that motor which is geared to the larger drivers will, by reason of its lower speed and consequently greater slip, take more than its fair share of the load. In practice this difficulty does, however, not arise. With reasonably good workmanship there should be no sensible difference in the size of the wheels; but even if we admit the possibility of there being a difference of a half per cent in the diameter of the wheels, this would, with the usual slip of three per cent, only mean that the motor geared to the larger wheels develops eight per cent more, and the other eight per cent less, than its normal power. The larger wheels will develop sixteen per cent more tractive effort than the smaller wheels, and having thus a greater wear, the difference originally existing will diminish in service. For the same reason, any tendency to wear unequally, say, in consequence of unequal material, is counteracted by the slip-adjustment of the motors. This point has been tested practically by the makers of the Simplon three-phase electromotives. It was found that if originally a slight difference in diameter of the drivers had been permitted to exist, after a short time this had vanished. That is as regards the condition on one electromotive; but if we come to the case of a train being hauled by two engines, then a sensible difference in the size of their wheels may exist. In this case it is necessary to artificially adjust the slip so as to make each motor take half the load. This problem has been solved by Mr. v. Kando in the electromotives which he designed for the Italian State railways. In these engines only liquid resistances are used in the rotor circuit for starting and speed regulation. The liquid is raised or lowered in the rheostat chambers so as to cover more or less of the contact plates, and the level of the liquid is controlled by a solenoid under the influence of the working current. The working current, and therefore also the tractive effort exerted by each motor, is thereby automatically kept constant, notwithstanding any difference that may exist in the size of the drivers on the two electromotives. Incidentally, it may be mentioned that this method of liquid rheostat control has also the advantage of a perfectly constant acceleration during the starting period—a point which makes for comfort of travel in a three-phase train.

The third objection advanced by theorists against three-phase traction is against the waste of energy consequent on rheostatic speed control and the inability to run at more than synchronous speed so as to make up for lost time. The obvious remedy for the last-named difficulty is to fix the time-table so that the

synchronous speed should be high enough for making up lost time and to employ motors which can run economically at less than synchronous speed. As a matter of practical experience three-phase trains are not more unpunctual than any other kind, steam not excluded. A train pulled by a series motor (d. c. or a. c.) runs slower on an up-grade or if abnormally heavy; this is one of the characteristics of the series motor, and it is valuable, because it limits the excess load thrown on to the source of power; but it is clearly not a condition making for good time-keeping. With a series motor time lost cannot be recovered on an up-grade, whilst with a three-phase motor the speed on an up-grade may be kept practically the same as on the level or on down-grades, so that the process of gaining time is not restricted to the easy parts of the line.

The problem of speed control without rheostatic waste has been solved in various ways. One of the simplest and generally adopted solutions is that of cascade (*series*) and single working. If the two motors are put into cascade connection the speed is halved. The cascade is used in starting and on heavy grades (unless time has to be made up), and on the easy grades or on down-grades the motors work singly—that is to say, in simple parallel connections. Intermediate speeds may be obtained by some pole-changing device. Ordinarily, such devices have to be applied to stator and rotor, but in some of the Simplon electromotives only the stator is arranged for pole-changing, the rotor being a squirrel cage. In this arrangement the advantage of cascade-working has to be given up, but the system has the merit of great simplicity. The number of poles may be changed from twelve at starting to eight, six, and four at top speed. Thus, four different speeds, all without rheostatic waste, are possible. The single bars in the squirrel-cage rotor are connected at their ends by resistance-connectors made of an alloy having a high temperature co-efficient. At starting the rotor current is large and heats up these strips, thus automatically providing what is technically termed a starting-resistance. When the motor is running the current is less, and by reason of the fanning action of the connecting-strips these get cooled so as to bring their resistance down to a permissible amount. Thus the efficiency of the motor when running under load is only a few per cent less than that of a motor with a wound rotor. A valuable feature of the three-phase system is the automatic recuperation of current whenever the speed exceeds synchronous speed by a few per cent; and, connected with this property is the further advantage that it is impossible for a train to race on a down-grade. Obviously recuperation can only take place if power is given to the motor. This is provided partly by the electromotive itself and partly by the train pushing it on a down-grade. This means that the train is braked in front only, and railway engineers have raised the objections that such a method is contrary to the accepted rules for safe working, which require that even on a down-grade all the couplings should remain in tension, which means that each coach must be independently braked. Here we have again a case where the theorists' objections have been proved to be without foundation in actual practice. It is no doubt objectionable to brake a train in front only, if the braking action is jerky; but with the automatically controlled liquid rheostat the braking comes in quite gradually, and is throughout so even that it has been found possible to permit a higher down-grade speed with recuperation than with ordinary braking. On the Italian State Railways the regulation permits on heavy down-grades a speed of thirty kilometres per hour for steam trains, but the electric goods trains are permitted to run at forty-five kilometres per hour. This concession is not extended to passenger trains. Nevertheless the economic effect is considerable. Recuperation saves 17 per cent on the coal bill, and this amount is sufficient to provide for interest and sinking fund on the electrical plant at the generating station.

One advantage of three-phase traction over steam traction is the lessened weight of the locomotive in comparison with its tractive force and power. As an example, we may take the Giovi line in Italy, where steam trains, consisting of 310 tons of rolling-stock and 202 tons of locomotive (one in front and the other at the back), have been replaced by three-phase trains, consisting of 380 tons of rolling-stock and two electromotives, each weighing 60 tons (also placed front and rear). Thus there has been a saving in total weight of 12 tons, and at the same time an increase in useful weight hauled of 70 tons. The average grade of this line, over which passes the whole traffic between the Port of Genoa and the Plain of Lombardy, is 27 per mille, and the maximum is 35 per mille. This traffic is now worked with forty electromotives, each of 60 tons weight. These engines have five driving-wheels connected to two eight-pole motors by gear-wheels and rods. The pressure of each driving-axle is 12 tons. Each electromotive develops 2,000 horsepower at the hour-rating; thus 1 horsepower is obtained for each 30 kilogramme weight of engine.

(*Balance of this paper will be published next month.*)

BIG ELECTRICAL MEN MEET TO EXCHANGE IDEAS.

At the invitation of the Association Island Corporation, over one hundred and fifty guests, composed of representative men in the electrical industry and others not directly connected with the electrical business were invited to spend three days during the first week in September at "Camp Co-operation."

Association Island is located in Lake Ontario near Sacketts Harbor, New York, and has been used as a conference headquarters for some time by the manufacturers of incandescent lamps.

Central stations, jobbers, contractors and electrical manufacturers, as well as practically all of the national electrical societies were represented at this gathering, which was really a "congress of governors." The purpose of the meeting was to promote a closer co-operation among the various branches of the industry and to discuss such questions as important in the immediate future development of the electrical business.

This gathering marks an epoch in the history of electrical development. Never before have the captains of an entire industry met together on common ground to work for the advancement of the industry as a whole without thought to their individual interests.

There were numerous addresses by prominent men from every branch of industry. Mr. Samuel Insull spoke briefly of his early association with Mr. Edison at Menlo Park and touched on the early cost of manufacturing incandescent lamps. A cost analysis for one month in 1883 showed that the expense of making each lamp was from $1.50 to $1.75, the retail sales price being 35 cents.

Lighting a Diner with Concealed Fixtures

DANIEL WOODHEAD

The problem of correct lighting of railway cars is rapidly taking on the appearance of a movement in the right direction. It is not so long since electric lighting was practiced in steam railway cars with no great degree of efficiency; in fact, it was not until the advent of the tungsten lamp, that train lighting for all classes of service by means of electricity was practical.

The tungsten lamp brought its advantages in the increased efficiency of the lamp, and in the improved quality of the light. It made possible the universal use of a clean convenient illuminant. At the same time, it brought with it one disadvantage which, while not recognized as a disadvantage at the outset, is now being recognized almost universally as a drawback, namely: eye strain due to the intense white light of the tungsten filament lamp. This has been modified from time to time by the use of frosted and opalescent globes and by the use of diffusing glass-ware, but it has seemed almost impossible to conceal the lamp filaments with any degree of success. Then too, the covering of the lamps by means of diffusing glassware did not entirely eliminate the glare and its deleterious effects. The light source was still too small and of too high intrinsic brilliancy.

Dr. Ferree in his recent article read before the "Illuminating Engineering Society" at Pittsburg, brought out some very pointed effects of exposed lighting on the eye. Not the least of these is the effect of varying light intensities on the eye under different systems of illumination. He has shown most conclusively that with indirect lighting the intensity may vary between 1.5 and 7 foot candles without any appreciable effect on the eye, while with direct lighting or exposed lights, a variation even as small as .3 of a foot candle brings appreciable defect in the lighting.

Interior View of the New Burlington Diner Lighted by Indirect System. Lamps are Contained in a Porcelain Enamel Trough Back of the Deck Moulding. This View was Taken Entirely by the Artificial Light of the Indirect System and the Photograph was In No Way Retouched. Exposure was 20 Minutes, No. 16 Stop.

Such facts must be of value to those interested in the proper lighting of trains, for it is a well known fact that the candle power of the lamps vary directly with the voltage, and we know further that up to this time there has not been produced a machine which will be constant for all conditions of load and speed.

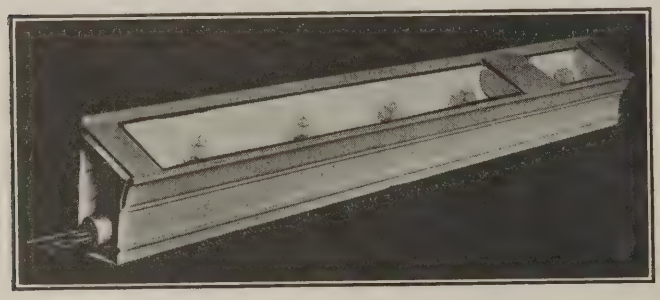
Here then is a method of lighting which is to a greater extent than any other, independent of the voltage regulation.

These facts become even more true in the system recently installed in the Burlington cars. A large number of small units are used at frequent intervals, all tending toward better distribution and diffusion. During the test one-third of the lights were cut out temporarily, and aside from a momentary flicker, there was no appreciable difference in the light intensity. On questioning those present, they were unanimous in the opinion that there had been no change in the lighting intensity.

It is a well recognized fact that a bright spot of light or a bright body of light within the range of vision, attracts the eye. Either consciously or unconsciously the eye is aware of the presence of such light and is continuously passing through a series of accomodative efforts in an attempt to regulate the quantity of light falling on the retina.

It is also a well known fact that a light source within the range of vision, causes eye fatigue, the degree of fatigue varying with the size and intensity of the light source. To illustrate: An area of 1 sq. in. emmiting a thousand lumens, would prove very disastrous to the eye—whereas an area of 1000 inches emitting 1000 lumens, would be very comfortable and efficient light as far as the eye itself is concerned. If such methods of lighting are defective in the house, office or store—consider what they must be in railway cars where there is continual shifting of the light with reference to the observer.

This problem of eye efficiency and eye ease was early recognized by the Central Electric Company; and through efforts and experiments, an attempt was made to bring into service on railway cars a lighting system similar in effect to that produced by the Alexalite. Naturally, a fixture was employed, and a very



Porcelain Trough Lighting Unit Showing Location of Conduit and Lamps

effective illumination secured by incorporating an Alexalite bowl which is now a standard indirect car lighting fixture.

Up to this point the source of trouble, namely: exposed light—had been removed; obviously, the next step was to remove the container of the source of light and give the car deck full opportunity to act as a secondary lighting source, and in order to secure the greatest efficiency the secondary light source must be unobstructed.

A car deck at best offers but a small surface on which to diffuse the light (compared with the floor area, it is about three-fifths) so that any system of illumination which is arranged so that the entire ceiling area can be utilized for diffusing surface, must be looked upon as distinct improvement.

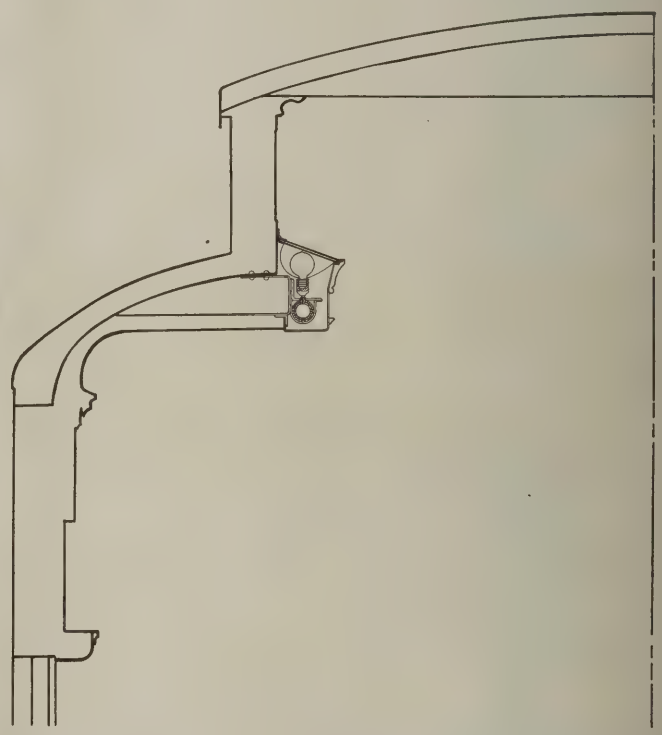
This problem was undertaken by the Burlington Railroad in conjunction with the Central Electric Company; and a test car was assigned for purposes of test.

How well this experiment has succeeded can be judged to some extent from the photographs here shown; but to get a real appreciation of the effect of this system of lighting, it is necessary to see the car. Imagine if you will, a car with the decks clear, with a soft comfortable light throughout the entire car; no variation in light intensity—nothing but light, with the source concealed.

The following is an engineering report relating to the lighting effect of the cars: The cars here shown are in construction—standard six section, Burlington diners built by the Pullman Co. with dining room proper 38 ft. in length. The deck moulding in which the lamps and reflectors are contained is set in the place of the standard car moulding and a place for it is made by setting back the angle plate in order that undue prominence will not be given to this moulding. The car body is finished in gray with red and silver trimmings. The moulding, which is a container of the reflector, is finished in cream enamel, as is also the upper deck. Chairs are finished in mahogany with leather and the carpet is of green with an old rose figure.

The dining room proper contains six sections, each section being lighted by one four foot unit on either side, each unit containing four 15 watt G-18½ clear lamps. Starting six inches from the end of the reflectors, the lamps are spaced at intervals of twelve inches.

The arrangement of the lamps and circuits is such that one lamp can be cut out of each of six units at a time, and practically any intensity up to the maximum

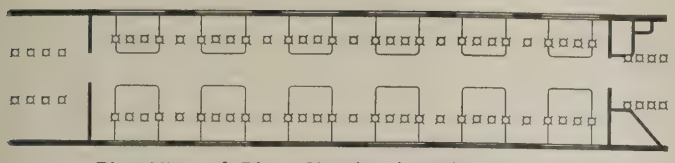


Cross Section of the Dining Car Showing Location of the Lighting Units

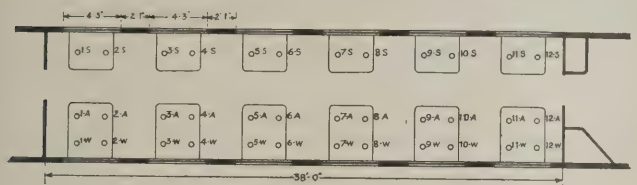
can be obtained at will. The total number of lamps used in lighting the dining room proper and vestibule are 74-15 watt lamps. The system is 60 volt head end and a total of 18½ ampere hours is the current consumption. The kitchen is lighted by Benjamin Clusters, using G-18½-15 watt frosted lamps; also individual G-18½-15 watt frosted lamps.

Between the deck beams on either side there is a one foot unit containing 1-15 watt lamp for the purpose of keeping the diner ceiling at an equal intensity. The reflector is designed so that the maximum amount of light will be thrown out toward the center of the ceiling of the car and thus avoid high lights over the trough which generally accompanies this form of lighting, the intent being to have the ceiling of an even intensity and free from bright spots and shadows. The reflector is made of No. 20 steel and has been given three coats of fired enamel.

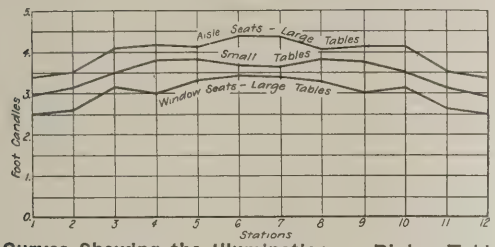
Inside of the trough proper and directly beneath the reflector, there is a 1½ inch conduit to which are attached at proper intervals condulets with a galvanized iron cover and to the latter is fastened a brass shell



Plan View of Diner Showing Location of Lamps



Plan View of Diner Showing Location of Test Stations



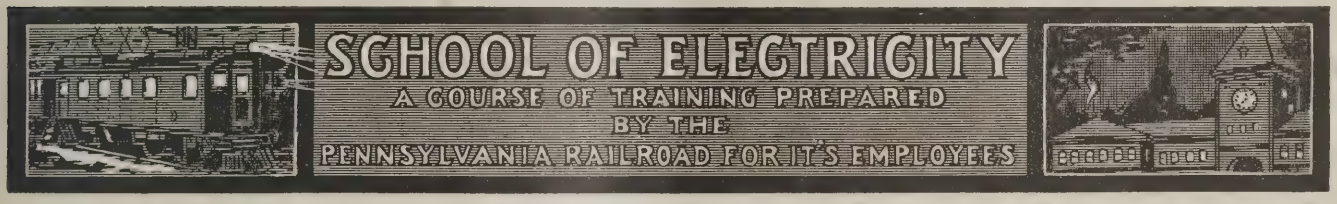
Curves Showing the Illumination on Dining Tables

socket. The entire lighting system being a "conduit job," the socket extends to within ⅛ inch of the reflector and is arranged so that when the lamp is set in the socket, the base of the lamp will not come within the area of the reflector, thus doing away with any absorbtion of light by the socket. Particular attention has been given to these small details in order that every available bit of light may be used, and thus make it as efficient as possible from the lighting standpoint.

Over the reflector is placed a two section clear glass panel (⅛ inch thick) laid in a brass frame which is for the purpose of keeping out dirt and dust which would necessarily accumulate. By placing the glass cover at an angle the collection of dust or dirt is minimized since constant vibration shakes down collected cinders and dust. For cleaning process, all that is necessary is that the glass panel be wiped with a dry cloth.

There is a slight loss here in absorption by the glass, but this is easily offset by the gain in keeping the reflector free from dust and dirt, and it provides a most simple method of keeping the equipment clean, since all that is necessary is the wiping off of the glass, which will require less time than required to clean any other fixture now in use.

Additional test made in this car at stations designated on the accompanying diagram show an average lighting intensity throughout the car on a plane 30 inches from the floor of 3.91 foot candles.



DECIMAL FRACTIONS.

It is of great importance that a thorough knowledge of decimals be possessed, as they are constantly used in making calculations. They are much easier to use than common fractions, but in some cases the common fractions are most convenient.

The divisions of anything into tenths, hundredths, thousandths, etc., are called Decimal Divisions. One or more of these decimal divisions of a unit forms a Decimal Fraction, commonly called a Decimal. This term is derived from the Latin word *"decem,"* meaning ten.

Since tenths are equal to ten times as many hundredths, hundredths equal to ten times as many thousandths, etc., decimals have the same laws of increase and decrease as whole numbers, the denominator being indicated by the position of the decimal point.

In this system of writing fractions, the value of a figure is decreased tenfold by each removal one place to the right from the decimal point. The first figure to the right of units or of the decimal point is read as tenths; thus 3.4 is read as three and four tenths. The second figure to the right of the decimal point or the one to the right of tenths is read as hundredths; thus 3.04 is read as three and four hundredths, or 3.24 is read three and twenty-four hundredths. The figure at the right of hundredths, or the third from the decimal point, is read as thousandths, etc.

A period placed before the decimal is called the Decimal Point.

Reading Decimals.

The whole number written before the decimal point is read same as usual; the word *and* always separates the whole number from the fraction when expressing the latter in terms of its denominator; the decimal is read as an integral number, and is expressed in terms of the denomination of the right-hand figure; thus 40.078 is read forty and seventy-eight thousandths.

The method of reading decimals often followed in business, and which is advisable to use in telephone conversation, is to repeat the figures comprising the whole number, call the decimal point merely "point," then repeat the figures following the decimal point. Then 40.078 would read as four, oh, point, oh, seven, eight.

Adding Decimals.

Always place the figures so that the decimal points come under each other. Add in usual way, placing the decimal point in the sum underneath the other points; thus,

48.756
301.28
10.3298

360.3658

Annexing ciphers after a decimal fraction does not alter its value. Each cipher inserted between the figures of a decimal and the decimal point is equivalent to dividing the fraction by ten.

The denominator of a decimal is read as if it were one, with as many ciphers annexed as there are figures after the decimal point.

Subtracting Decimals.

Place the numbers with the decimal points underneath each other and subtract same as usual; thus,

482.56
39.375

443.185.

Add a cipher to first number, as that does not change its value and makes the operation clearer.

To reduce decimals having different denominators to similar decimals, annex ciphers after the figures so that all have the same number of decimal places, as this does not alter their value; thus .5, .25, .465 and 3.015 may be written as:

.5 = .500
.25 = .250
.465= .465
3.015=3.015

To change decimals to common fractions, write the number, omitting the decimal point, supply the proper denominator and reduce to its lowest terms; thus, $.075 = \frac{75}{1000} = \frac{3}{40}$.

To change common fractions to equivalent decimals, annex ciphers to the numerators and divide by the denominator. Point off as many places in the quotient as there are ciphers annexed.

Many times the division, changing a common fraction to a decimal, is not complete. In such cases it is customary to either write the remainder as a common fraction having for its numerator the remainder and its denominator the divisor; thus, ⅓= .333⅓; or the sign + may be used to show that the division is not complete and that it may be carried further; as, .333+.

Multiplication.

Two decimals are multiplied like whole numbers, and from the right of the product point off as many places as there are decimal places in both factors; thus, $4.417 \times .34 = 1.50178$.

$$\begin{array}{r} 4.417 \\ .34 \\ \hline 17668 \\ 13251 \\ \hline 1.50178 \end{array}$$

Division.

This is performed the same as if the decimals were whole numbers. If the dividend (the number to be divided) does not have as many figures as the divisor (the number to divide by), ciphers are annexed to the dividend until the division is carried as far as desired. Judgment should be used regarding how far it is advisable to carry out a decimal.

In the ordinary business computation four or five places are sufficient.

The quotient is pointed off by taking as many figures from the right for decimal as the number of decimal places in the dividend exceed those in the divisor. If the quotient does not contain a sufficient number of figures, ciphers should be prefixed to supply the deficiency; thus, $.0075 \div 1.25 = .006$.

$$1.25).00750(.006$$
$$750$$

RATIO AND PROPORTION.

The relation of one number to another of the same kind is known as Ratio. This may be expressed in two ways, either by arithmetical or geometrical ratio; thus the ratio of 4 to 8 is expressed as $^4/_8$ or $\frac{1}{2}$, which is the geometrical ratio, and is the ratio always referred to unless otherwise mentioned. The constant difference between numbers in a series, as 4, 8, 12, 16, 20, 24, etc., which is 4, is the arithmetical ratio, but this is seldom used.

If the relation of one number to another is sought, the first number mentioned is the dividend, the second is the divisor, but if the relation between the two numbers is desired, either may be considered as the dividend or divisor.

The numbers so compared are known as the terms of the Ratio. The first number is the antecedent and the second the consequent.

Inverse Ratio.

When expressing the ratio between two quantities it is understood to mean the "Direct Ratio" or comparison between them in the order in which they are mentioned, unless otherwise specified. An Inverse or Reciprocal Ratio of two quantities changes the relative position of the terms of the ratio. In expressing as a fraction the ratio of 3 to 10, it would be written $^3/_{10}$, but the inverse ratio of 3 to 10 would be $^{10}/_3$.

Examples showing the application of "Inverse Ratio" are numerous. The resistance of electrical conductors of the same material varies inversely as their areas of cross-section. That is, if a conductor has twice the cross-sectional area, its resistance would be half that of the other of same material. The intensity of illumination on a surface varies inversely as the square of its distance from the source of the illumination; that is, if a paper is held a distance of 2 feet from a lamp, the illumination on the paper will be four times as intense as when it is held at the same angle and 4 feet away from the lamp, or in the inverse ratio of 2^2 to 4^2 which equals $^{16}/_4$ equals 4.

An equality of ratios is known as a Proportion; thus $1:2::6:12$ is a proportion, and is read one is to two as six is to twelve.

There must be four terms in a proportion, viz., two antecedents and two consequents. In the above proportion 1 and 6 are the antecedents and 2 and 12 are the consequents.

The first and last terms are also called the extremes, and the second and third the means. The product of the extremes is equal to the product of the means. From this it follows that the product of the means divided by either extreme will give the other extreme, and the product of the extremes divided by either mean will give the other mean.

By considering cause and effect as applied to proportion, a great many problems can be easily solved. Let the first term be considered as a cause and the second the effect produced by this cause, the third a similar cause and the fourth the effect produced by this second cause. This may be applied in the following problem: How high is a building that makes a shadow of 162 feet long when a flag-staff whose height is known to be 60 feet casts a shadow of 72 feet?

Solution: The flag-staff is the cause of the shadow and the shadow is the effect, similarly with the building and its shadow. Then we may state this as a proportion:

$6:72::X:162$. The quantity X is the unknown quantity which we are to solve for. From the product of means and extremes we can easily find this:

$$\frac{60 \times 162}{72} = 135,$$ the height of the building.

In like manner the height of a stack or other object may easily be found.

Proportion may be written as an algebraic equation; as $a:b::c:d$, which is an application of the same principle, namely, an equality of two ratios.

Many times the expression of a formula or rule may be more clearly seen and understood by stating it in the form of an equation; but some people have a peculiar idea that an equation, or anything of a similar nature pertaining to mathematics other than the simple processes, can be understood and applied only by those having an excellent understanding of algebra and higher mathematics. Such an idea is erroneous. Most formulas with which we shall have any occasion to deal can be solved by arithmetic.

The letters *a, b, c* and *d* mentioned in the propostion above are used to represent quantities, and may have any value whatever so long as the ratio of *a* to *b* remains the same as the quantities represented by the ratio *c* to *d;* this is also stated:

$\frac{a}{b}=\frac{c}{d}$, $ad=bc$, $a=\frac{bc}{d}$, $d=\frac{bc}{a}$, $b=\frac{ad}{c}$, $c=\frac{ad}{b}$, so that when any three of the quantities are known the missing number may be solved for.

Involution.

This is the process of multiplying a number by itself a certain number of times. The product thus obtained is said to be a certain power of the original number. If the number is multiplied by itself once, the result is called the square of the number; thus $3^2=9$ is read three squared equals nine. Nine is, therefore, the square of three.

The figure placed above and to the right of a number is called the *exponent* or *index* of the number, and indicates how many times the number will be taken as a factor.

When the square of a number is multiplied by the number, the result of the cube of the number. The expression of 8^3 is read eight cubed. It may also be written $8 \times 8 \times 8$, and is equal to 512.

If the number to be raised to a given power is a fraction, both the numerator and denominator should be raised to the same power as indicated by the exponent; thus, $(^{11}/_{15})^2 = \frac{11 \times 11}{15 \times 15}$.

A little rule that is many times handy in finding the square of a mixed number if the fraction is $\frac{1}{2}$, as $2\frac{1}{2}$, $5\frac{1}{2}$, etc., is as follows:

Multiply the next smaller number by the next greater and add $\frac{1}{4}$. For example, $(3\frac{1}{2})^2$ is equal to 3 (the next smaller number) times 4 (the next larger number) $+\frac{1}{4}=12\frac{1}{4}$, $(10\frac{1}{2})^2$ is equal to $10 \times 11 + \frac{1}{4} = 110\frac{1}{4}$.

From equation No. 5, in E-2, it was stated that the amount of power lost in the electric circuit and which was dissipated as heat varied as the square of the current; this was expressed as $W=I^2R$. Consider two conductors of same size and material and same length, one carrying 10 amperes, the other carrying 15 amperes; how do the relative amounts of lost power compare?

Solution.

In the ratio of 10^2 to 15^2 read in the ratio of ten squared to fifteen squared, and this may be expressed as $^{10}/_{15}{}^2 = {}^{100}/_{225}$, or as 4 to 9, ∴ the conductor having a current of 15 amperes has $2\frac{1}{4}$ times as great a copper loss as the one carrying 10 amperes. To overcome this, a larger conductor should be used to reduce the resistance accordingly.

Problems

Third Lesson.

17.—What is a ratio? Distinguish between arithmetical and geometrical ratio.

18.—How does inverse ratio differ from direct ratio?

19.—If the resistance of two similar conductors varies inversely as the square of their diameters, how does the resistance of a rod 460 mils in diameter compare with one having a diameter of 162 mils?

20.—If 15 men can erect a certain piece of line in 36 days, in what time can they perform the same work with 9 additional men in the force, assuming that all are equally as efficient as the fifteen?

21.—The top of a wire fixture on a bridge casts a shadow 96 ft. from a point immediately underneath and measured along the track, at the same time a 10-ft. pole in a vertical position makes a shadow 15 ft. long. How high is the fixture above the track?

The balance of the course in Mathematics will be published next month and this will be followed by a lesson on "Magnetism."

LESSON 22

ELECTRIC STORAGE BATTERY CO. SYSTEM.

The new car lighting system designed by the Electric Storage Battery Co. is radically different from any other car lighting equipment in use in this country. It is a constant voltage system rather than a constant current system, so generally used in car lighting work up to this time.

Generator.

The generator is of the Rosenberg type, described in our August, 1913, issue, Lesson No. 19, but this has been redesigned to operate at constant voltage instead of constant current as the original Rosenberg machine operated. This generator has many characteristics which seem impossible and directly opposite to what we find in most generators, so it will be well for car lighting men to study this lesson very carefully in order that the subject may be thoroughly understood. The pole shoes of this generator are extra heavy, as shown by the diagram, Fig. 127, and are made of laminated iron (thin sheets of iron vanished and bolted together). The frame and neck of the poles to which the pole shoes are bolted, are made of cast steel which retain a certain amount of permanent magnetism.

Referring to the diagram, Fig. 127, the primary field winding F1, which corresponds to the ordinary winding of the generator, produces a small amount of magnetism flowing across between the pole shoes, as shown by the arrow P. The armature whirling through this weak field develops a small electro-motive force in the armature coils, across the brushes B1-B1. These brushes, however, are directly short-circuited by a heavy copper strip so that there will be a comparatively heavy short circuited current flow through the coils of the armature. This creates a magnetic flux perpendicular to the primary flux, which circulates through the heavy pole shoes and the armature as represented by the curved arrow K. This secondary magnetism, produced by the short circuiting current, is the principal magnetism of the machine and generates a practically constant voltage across the brushes B2-B2 which furnish current to the lamps and battery. It should be noted that this principal magnetism of the machine does not pass through the generator frame, but simply circulates through the heavy pole shoes and the armature.

The series winding F2 carries the total generator current and is so proportioned as to slightly over-balance the magnetism of the load current circulating through the armature coils between the brushes B2-B2. This series field performs a double service of balancing the armature reactions (which prevents the principal magnetism from shifting which would cause brush sparking) and it also over-compounds the voltage with a heavy load, so as to compensate for the increased voltage drop through the armature coils. In case the battery current tends to rise to an excessive value, however, as might be experienced with a battery completely discharged, the opposing action between the magnetism of the series field and that of the armature reaction produces a considerable leakage of the magnetic lines from the pole shoes to the frame.

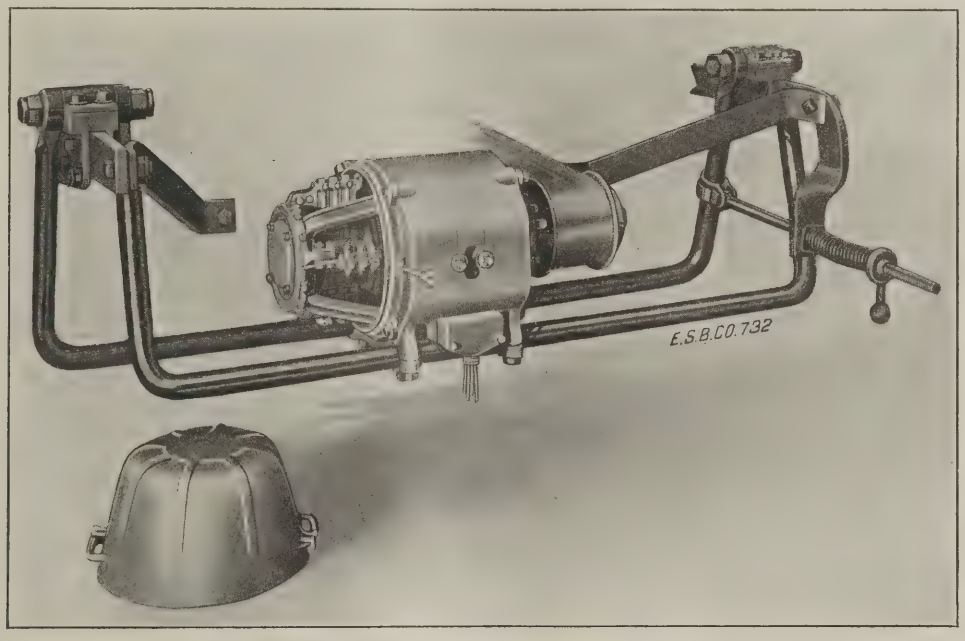


Fig. 124. E. S. B. Generator Showing New Suspension. Cover Removed to Show Brush Construction

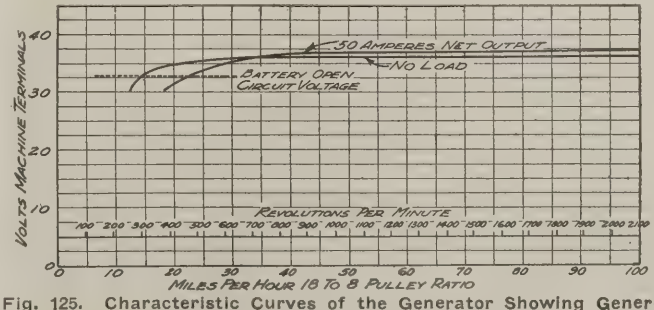

50 AMPERES NET OUTPUT
NO LOAD
BATTERY OPEN CIRCUIT VOLTAGE
VOLTS MACHINE TERMINALS
0
10
20
30
40
REVOLUTIONS PER MINUTE
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100
0 10 20 30 40 50 60 70 80 90 100
MILES PER HOUR 18 TO 8 PULLEY RATIO

Fig. 125. Characteristic Curves of the Generator Showing Generator Voltage at Various Speeds

This leakage magnetism returns through the small neck of the primary field and chokes down the primary magnetism P, thus reducing the generator voltage somewhat and protecting the dynamo from over-load.

An important advantage of this type of machine lies in the fact that it generates the same polarity with either direction of rotation so that no pole changer is required.

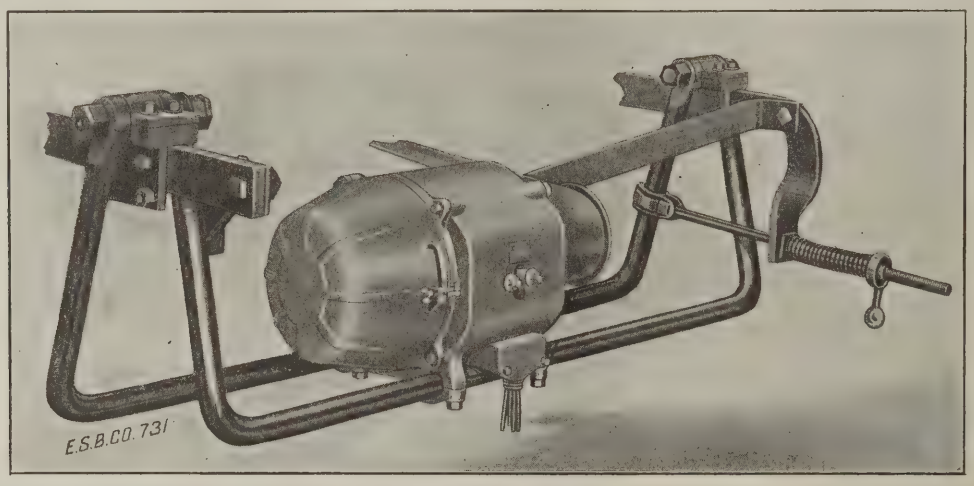


Fig. 126. Generator Mounted on Suspension with Cover Applied

The reason for this is evident, for the primary field F1 is always maintained in the same direction and the small electro-motive force generated across the short circuited brushes B1, B1 reverses when the direction of rotation is reversed. This causes the short-circuiting current, which creates the principal magnetism of the machine, to also reverse and the double reversal both in the direction of rotation and in the principal field magnetism at the same time, causes the polarity of the load brushes B2, B2 to be always in the same direction.

The Controlling Bridge.

As stated above, this equipment controls the generator voltage practically constant, regardless of load (except overloads as above noted), speed, or state of charge of the battery. This is accomplished by automatically reducing the current flowing through the primary field F1, as the train speed increases. It will be noted that this field winding is connected at opposite corners of what is called a Wheatstone bridge (W.) Fig. 127. This bridge is made up of four resistance units, two of which X are of ordinary resistance wire, while the other two Y are of special iron wire ballast resistance, such as has been used extensively for controlling current in Nernst lamps, etc.

Iron wire that is hot has a considerably lighter resistance than the same wire when cold, and this fact makes these iron wire resistances have the peculiar property of maintaining constant current regardless of the voltage impressed within certain limits. That is, if the voltage tends to rise, the current through the iron wire increases, causing the wire to become hotter; its resistance will then be greatly increased and so choke down the current to normal value. On the other hand, if the voltage tends to fall off and the current decreases, the heating of the wire will be reduced and its resistance greatly decreased, allowing normal current to flow. Although the current through the iron wire resistances Y does vary slightly, for all practical purposes it can be assumed as constant at a little less than 5 amp.

When the armature begins to rotate, the permanent magnetism in the frame and the neck of the pole shoes will generate a slight electro-motive force across the short-circuited brushes B1, B1. This circuit will cause a fairly heavy current to flow through the armature coils, and will generate the magnetism indicated by the arrows K, which is the principal magnetism of the machine, as explained above. (As explained in Lesson No. 2, current flowing through the coils of an armature will create magnetism just as current flowing through the windings of a solenoid does.) This principal magnetism then gradually builds up the voltage across the brushes B2, B2. While the generator is building up there will be a strong field current flow through the primary field F1, which will assist the machine to pick up. This field current is simply the difference between the amount of current flowing through the Y resistance and the X resistance of the bridge. If the voltage is below normal the current

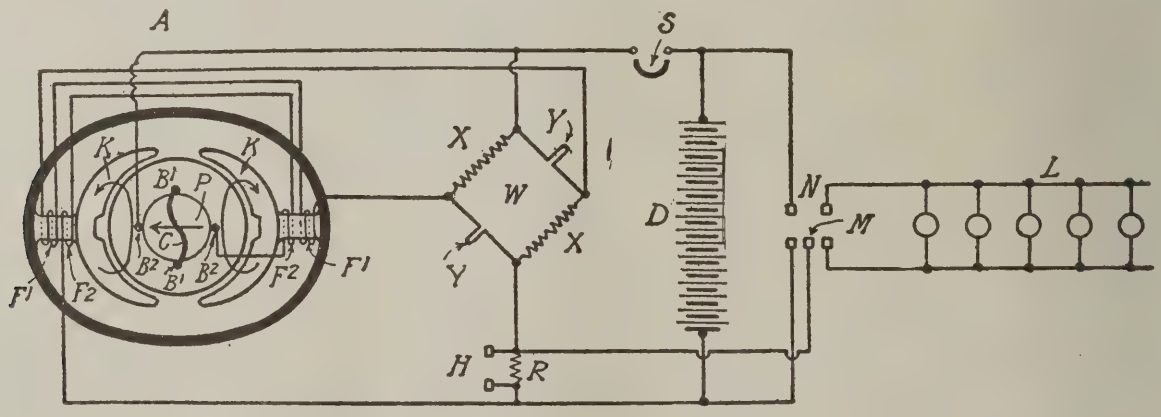


Fig. 127. Wiring Diagram of E. S. B. System

through X will be very low but nearly the full 5 amp. will be allowed to flow through Y. The excess of current in Y over that in X must flow through the field winding F1. This flows from the right hand corner of the square, as shown, through the field coils and back to the left hand corner of the square.

The current is taken into the bridge at the upper corner, where it divides, 5 amp. flowing through Y and something less than 5 amp. flowing through X, depending upon the voltage of the machine. The 5 amp. which passes through the resistance Y again divides at the right hand

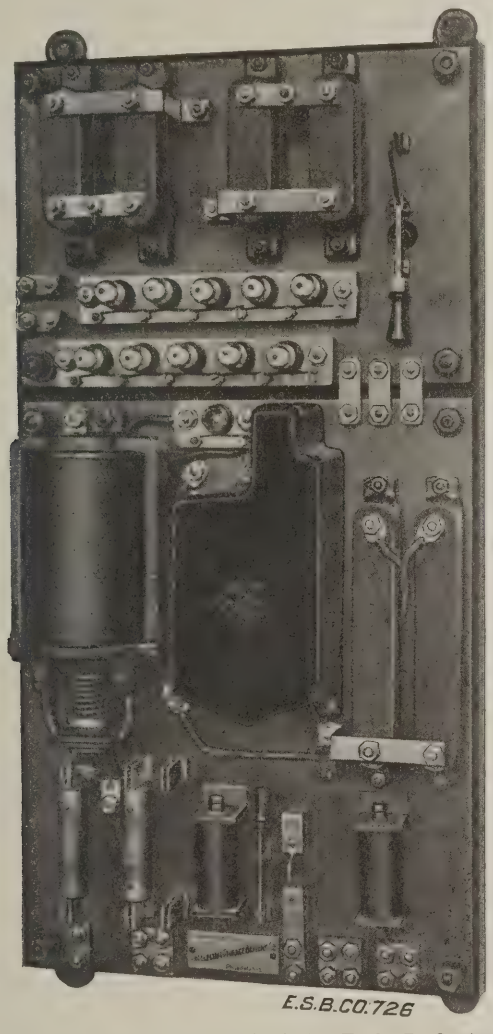


Fig. 129. Control Panel of the E. S. B. System

corner of the square, part flowing through the resistance X, the amount depending upon the generator voltage, and the balance flowing through the field coils F_1 and back to the left hand corner of the bridge, where the field current unites with the upper X current and passes through the resistance Y to the negative. It is evident then that the amount of field current in the primary field F_1 is simply the difference in current through the resistance Y and X.

As the voltage of the generator comes up to normal at 36 volts, as shown by the diagram Fig. 125, the amount of current flowing through the resistance X gradually increases to nearly 5 amperes and the field current accordingly gradually decreases as explained above, compensating for the increase in speed and keeping the generator voltage from rising above normal. At a speed of approximately 30 miles an hour, the current through X will be equal of that through Y, so no current will flow through the field windings F, and the primary magnetism P will be simply the permanent magnetism of the neck and frame of the generator. At higher speeds the current through X becomes greater than that through Y and a reverse current will flow through the field winding F_1, actually bucking the permanent magnetism of the machine slightly in order to maintain constant voltage at the higher speeds.

In case it ever becomes necessary to give the battery a high voltage over-charge, this can be done by simply opening the switch H, which inserts the resistance R in the bridge circuit. This resistance R is automatically short circuited when the lights are turned on at the switch M, so as to prevent the high voltage coming on the lamps.

We have seen from the above that when the voltage across the bridge is lowered below normal, the field current will correspondingly increase. Cutting in the resistance R is equivalent to lowering the voltage across the bridge, so the field current will increase and the total voltage of the generator increase by the number of volts drop in the resistance R. This is approximately 3 volts so that an over-charge at 39 volts can be given the battery whenever desired. In the operation of one of these equipments on the Santa Fe for the past year, however, it has not been found necessary to give the battery this high over-charge. The 36 volts normal seems to be sufficient to keep the battery in good condition.

The Automatic Switch.

The automatic switch of this equipment has many novel features which are of special interest. Instead of haveing a simple shunt and a series coil as other automatic switches described in the previous lessons, a third auxiliary coil is added. The detail of the switch connections is shown in the accompanying diagram Fig. 128, and it will

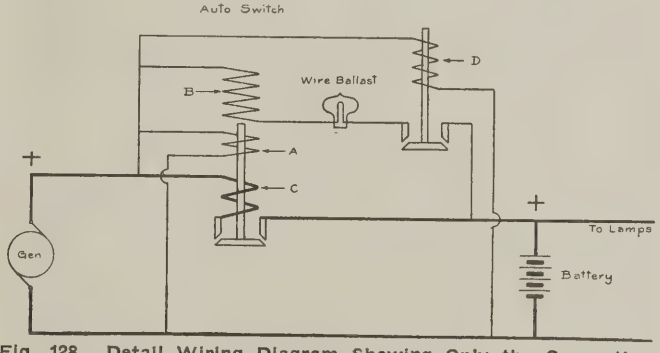


Fig. 128. Detail Wiring Diagram Showing Only the Connections of Automatic Switch

be noted that the main shunt coil A connects from positive generator to negative generator. The series coil C carries the main generator current and the auxiliary shunt coil B connects between the positive generator and positive battery; or in other words, this coil B is simply connected across the automatic switch. The main shunt coil A is not strong enough to lift the switch alone or even to keep it in without assistance from either the series coil C or the auxiliary coil B. The magnetism of the auxiliary coil B opposes that of the main shunt coil A when the generator voltage is below that of the battery and this coil B is much larger and stronger than A and is wound for a low voltage.

In order to prevent the full battery voltage from coming on coil B when the generator is dead or at very low voltage, a small relay D is provided which closes the circuit through the coil B when the generator gets up to about 26 volts. This also opens the circuit of the coil B when the generator voltage falls below 28 volts. In order to further protect the shunt coil B from excessive current an iron wire resistance unit is placed in the circuit which limits the current to two amperes.

After the generator voltage has built up to 30 volts, the coil B begins to operate and at first bucks the coil A,

but when the generator voltage equals that of the battery there will be no current flowing through B, but the coil A alone is not strong enough to lift the switch so that it will stay open. When the generator builds up still higher and its voltage exceeds that of the battery, the current through the coil B will be reversed and the magnetism of the coil B will assist that of the coil A in closing the switch. The coils are adjusted so that the switch will close when the generator is 1 volt higher than the battery and as it operates upon the *difference* in the voltage instead of the total voltage, it does not depend upon careful adjustment of the switch. Even with a two pound weight tied to the switch plunger, the switch will operate satisfactorily. One volt across the coil B with the generator voltage above that of the battery will add about 50 per cent to the pull of the coil A and 2 volts across the coil B will add nearly 100 per cent to the pull of the coil A. So it will be seen that a very small difference in the voltage will cause a powerful action in closing the automatic switch at the proper time.

As soon as the switch closes, it automatically short circuits the coil B, but the generator voltage being 1 volt above the battery, there will be a fairly strong current flowing through the series coil C which will assist the main shunt coil A holding up the plunger.

When the train speed again falls to about cutting in speed, the generator voltage will fall off to approximately battery voltage and this will cause the current supplied by the generator to battery and lamps to decrease. As stated above, however, the main shunt coil A is not strong enough to hold the switch in and as the auxiliary coil B is short circuited by the switch itself, the switch will drop open when the series current through coil C falls to about zero. The reverse current through this series coil from the battery to the generator is unnecessary with this switch and accordingly it opens with no arcing.

Lamp Voltage Regulation.

There is no lamp regulator whatever provided with this equipment, for the generator voltage never rises above 36 volts, and the lamp voltage is always less than this. The manufacturers state that by using 34 volt lamps, 2 volts excess of the generator voltage will not unduly strain the lamp and when the voltage falls to 32 on discharge, it will only be 2 volts below normal, so that the variation in c. p. will not be appreciable and probably no more than the resistance drop through most lamp regulators on dis-charge.

Thirty-two volt lamps have been used for the past year on the Santa Fe and no excessive burn-outs or lamp renewals have been experienced. This equipment went into service Nov. 7, 1912, between Chicago and Newton, Kan., and up to October 15, 1913, made a total of 160,000 miles. During that time there has been no light failure and no repairs to dynamos necessary except replacing a defective ball bearing, that bearing being smaller than the present standard.

During this time it has never been necessary to give the battery any terminal charging or over-charging en route, except that given by the axle dynamo at 36 volts. Water was added to the cells on the following dates only, Nov. 19, 1912, Dec. 31, 1912, Jan. 15, 1913, Aug. 12, 1913.

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Have you a copy of the Railway Electrical Engineer for June, 1913, or December, 1912, which you are willing to send in? We will credit your subscription with 20c each for either of these issues.

Practical Stunts

We pay a dollar apiece for practical stunts. Send in your ideas.

Battery Flushing Device.

There are a great many batteries ruined because of the fact that they are flooded when being flushed and the electrolyte overflows, wetting the outside of the tank or container. This usually develops grounds which eat holes in the tank, and the electrolyte runs out, causing an open circuit in the battery and light failure.

This can all be avoided by using proper care when the battery is flushed. It is pretty difficult, in fact almost impossible to tell when the electrolyte in the rear jar has been flushed to the proper level, unless some special device is employed. For this purpose, the writer has developed a filler as follows:

A simple copper trough with a lead pipe soldered to the lower end is bent so that it can be inserted into the filling opening of the cell. This lead pipe is made of just the right length so that when inserted and the trough rests on the top of the cell the tip of the lead pipe will just barely touch the surface of the electrolyte when the cell is filled to the proper depth. A flexible wire lead is then soldered to the trough and connected to one pole of the buzzer; another flexible wire lead is provided with a spring clip so that it may connect the other terminal of the buzzer to the post of any cell in the battery. By connecting this to a cell, three or four cells away from the one being flushed, the buzzer will ring when the proper amount of distilled water has been added, for when the electrotype in the cell rises so that it touches the tip of the filling pipe, it will close the circuit through the buzzer and the three or four cells of the battery included in the circuit.

Where the battery is flushed from the tank or barrel, a flexible rubber tube with lead tip can be used instead of the trough.—W. C. Burgess.

Short Circuit Commutator.

I have been very much interested in the stunts published in this column and would like to contribute a few myself.

When a short circuit occurs in the mica between two segments of a commutator the proper way to repair it would, of course, be to remove the injured mica and replace it with new. However, as many commutators are now built this would involve unsoldering the lead, removing the commutator from the shaft, making the repairs, replacing the commutator and resoldering; the whole day's work on a one hour job. In case the short circuit occurs, as it often does, at the outer edge of the segment and down next to the core of the commutator, I find a very good method is to drill a 1/16 in. hole into the mica as deep as the burn extends and then drive in a wooden plug dipped in shellac. This makes a permanent repair and is quickly done.

C. B. Jennings.

Shunt Fuse Trouble.

In looking over the question box in the September Railway Electrical Engineer, I note that SWE asked this question: "What conditions could come in an axle lighting system to cause the shunt field fuse to blow?" In addition to your answer given I wish to add:

First, that a failure of the automatic switch to close will blow the shunt fuse as this has the same effect on the fuse that an open circuit has although it does not affect the light. And this has caused shunt fuses to blow in practice.

Second, a badly sulphated battery will blow the fuse because it will take a very heavy field current to furnish the output of the dynamo at a very high voltage necessary to get the output of the dynamo through the batteries. A high resistance in a battery circuit will produce the same effect. If a battery jar is leaking so that the acid is very low, this can increase the resistance in the battery circuit and blow the shunt fuse.

I do not think that your third answer is correct because if some accident should happen that would prevent the resistance being inserted in the field circuit, the main current from the dynamo would blow the main fuse before the field current had increased enough to blow the shunt fuse. Of course, if the main fuse was too large and the field fuse was very close to the normal field current the field fuse might be blown before the main fuse. Should a car arrive at an inspection point with the shunt fuse blown, the most probable cause would be an open circuit or high resistance in the battery. Next, an open circuit in the lifting coil of the automatic switch or dirt in the contact, and if these two points were found to be correct, the equipment should have a thorough overhauling to be sure that there were no shorts or grounds on the equipment.

A. E. Voigt.

Under Cut Mica.

It happens that certain types of armature refuse to work satisfactorily unless the mica between the segments is undercut. In axle lighting armatures this cutting down of the mica almost invariably leads to trouble owing to the fact that the carbon and copper dust becomes mixed with oil and this paste is packed into the slots by the action of the brushes. This filling of the slots causes a partial short and the heat generated therein is sufficient to melt the solder from around the leads.

For this reason we do not think it advisable to under cut mica, but simply smooth off the commutator with emery cloth. With the new ball bearing generators, which do not seem to spill oil or grease into the generator if properly packed, this trouble may be entirely overcome. Mr. C. B. Jennings.

Prize Question Box

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

This ought to stir up some mighty interesting information, for we can all ask questions even though we don't have a big line of practical stunts to submit.

The names of the prize winners will be published each month and all the questions submitted will be answered by us in the same issue. (If we can't answer them ourselves, we will find somebody who can.)

Better send in your questions now, while you think of it.

First Prize

Motoring Car Lighting Generators.

Question. In testing out a type "A" Consolidated dynamo recently I found that it required considerably more current to run it continuously as a motor in one direction than in the reverse direction. The car was in the shops, had no belt on the machine, and the battery was fully charged. The equipment was controlled by an Everett regulator and in motoring, when the last step of resistance was cut in, the 50 ampere fuse in the machine circuit would blow, while when operating in the reverse direction the fuse would hold O. K. Will you please explain the reason for this action. M. F. Hand.

Answer. The fact that you blew a 50 ampere fuse in motoring the generator when running light would indicate that an abnormal condition existed. It must be borne in mind, however, that at this time the field current was weakened very greatly, the equivalent of probably 80 miles per hour speed. This machine, which was one of the earliest car lighting generators built, does not, of course, have an interpole as the modern machines do, so the 50 ampere current flowing through the armature coils would cause rather serious armature reaction (magnetism of current through armature coils) and this would greatly distort the weak field of the generator, as explained in lesson No. 2, March, 1912. When the generator runs in one direction the armature reaction crowds the main generator field to one side and when going in the other direction, it crowds it to the other side of the pole shoe.

In stationary machines the brushes of a generator are given a slight lead, that is they are set forward in order to keep them at the neutral point which is shifted on heavy loads due to armature reaction as explained above.

In car lighting generators, where the generator must run in either direction it is impossible to give the brushes this lead, we can only strike a happy medium by setting the brushes so as to commutate the coils where they are just half way between the pole pieces. Now if for some reason or other the brushes become shifted out of this position slightly, even possibly due to uneven wear of a loose brush, they will commutate at more nearly the neutral point when running in one direction than in the other. When the brushes of a motor are not exactly at the neutral point it will take more current to deliver the same amount of power than when the brushes are set exactly at that neutral point, and the farther the brushes are from this point the more current it will take. In other words, the armature current flows through some of the coils (depending upon how far the brushes are from the neutral point) in the wrong direction and this requires a greater total armature current to overcome the back action of these coils. This is probably the reason why your generator took more current in one direction than in the other.

Second Prize

Negative Plates Turning Brown.

Question. What would cause the negative plates of a lead storage battery to turn red or a reddish brown?

J. M. Brown.

Answer. The active material in a negative lead plate is, of course, supposed to consist simply of pure lead sponge, which is slate color when fully charged, and the active material of the positive plate lead peroxide which is a chocolate brown color. If the negatives are a reddish brown as you state, it would indicate that that particular cell had become reversed. This may be caused by local action due to impurities or short circuit between plates which would discharge that cell. Then when the lighting discharge current of the cells in series with it flows through this cell this current will act as a charging current in the wrong direction for this particular cell and reverse its polarity, making the negative plates lead peroxide, and the positive plates spongy lead.

Third Prize

Battery Tank Trouble.

Q. Why do the inside or back cells of 2-compartment train lighting batteries become pitted and leaky more than the front cells? I have to repair at least 20 back lead cells to one front cell.—J. M.

Answer. This undoubtedly is due to the fact that the back cells of the battery are usually filled too full when the battery is flushed because it is difficult to tell when the electrolyte has been brought up to the proper level. This will cause slopping over which will soak the wooden tray on that end and cause slight grounds on the tank. These grounds will soon eat holes in the lead lining of the tank.

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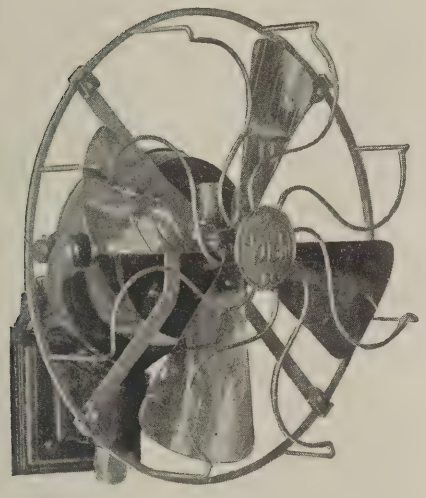

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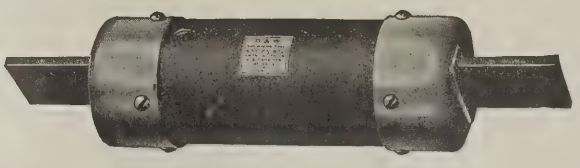

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of Service CHICAGO

This point is covered pretty well in the practical stunt submitted by Mr. W. C. Burgess, published in this issue. I would suggest that you adopt his scheme and I believe you will find the trouble with back jars greatly reduced.

Why Use a Multiplier Relay?

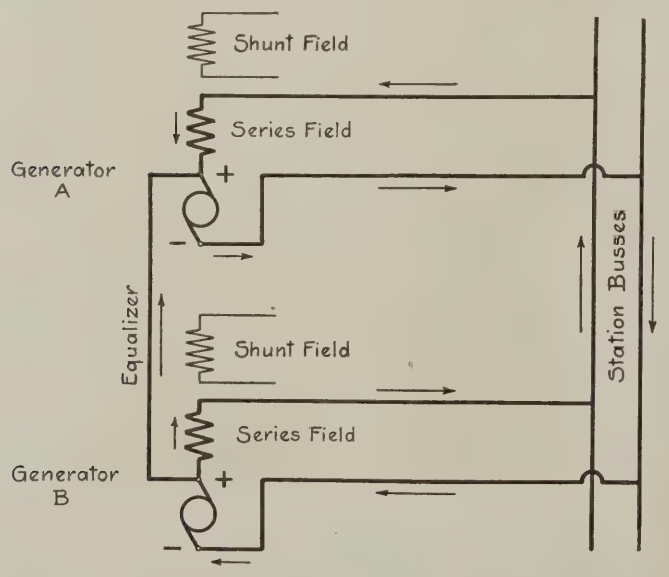
Question. Why is it necessary to use a multiplier or relay in connection with lamp regulator in a car lighting system?
G. R. F.

Answer. By referring to lesson No. 13, February, 1913, it will be seen the coil winding of the multiplier is placed directly across the lamp terminals; a lamp voltage slightly above normal will increase the pull of this coil on its plunger by a slight amount, and a low voltage will reduce the pull. This plunger compresses a small carbon pile, which is placed in series with the main winding of the lamp regulator, and this comprises a pretty big part of the total resistance in that circuit. The resistance of this carbon pile depends upon the pressure of the multiplier plunger. In this way a slight change in voltage, causing a slight change in current through the multiplier coil will cause a very great change in current through the main coil of the lamp regulator. This means that with the multiplier the lamp regulator will be very many times more sensitive than it would be if the main coil of the lamp regulator were connected directly across lamp terminals.

Generator Run as a Motor.

Q. If you have two generators connected in parallel on a switchboard, compound wound with equalizer between, and the steam on one generator is shut down while its switch is still in, would this generator, when run as a motor, run in the same direction or the reverse?—C. W. Frank.

Answer. As soon as the voltage of generator "A" falls below that of generator "B," due to the steam being shut off "A" and its speed reduced, current will flow through the system as indicated by the arrows in the



Wiring Diagram Showing Connections and Current Flow

accompanying figure. In other words, generator "B" will run generator "A" as a motor in the same direction it ran when operating as a generator. The current through the armature of "A" will be reversed and this fact might lead some to think that the direction of rotation of "A" would be reversed.

When machine "A" runs as a generator its armature coils are whirling through its magnetic field and a voltage is generated in these coils. If current is taken from generator "A," this current flowing through the coils of the armature will create magnetic lines around the coils of wire in the armature and the direction of these lines will be such that the repulsion between the magetism of the generator field and the magnetic lines around each of the armature coils opposes the rotation of the armature; it takes force to overcome this magnetic replusion.

When the steam is shut off machine "A" and its voltage falls below "B" it is driven as a motor and the current through the armature coils reverses. There is the same kind of a replusion between the field magnetism around each of the armature coils as when operating as a generator, but since the current through the armature coils is reversed this replusion will be in the opposite direction from what it was. It will, therefore, drive the armature in the same direction instead of opposing its rotation.

Field Fuse Trouble.

Q. What conditions would have to exist to cause the shunt field fuse of an axle generator to blow on account of a sticking dash pot?—C. R. Alexander.

Answer. Where the dash pot of the field generator sticks it will prevent field resistance being inserted on high speeds; it is absolutely necessary that this field resistance be increased on high speeds in order to keep the generator voltage down to normal value. Where this is prevented by the sticking dash pot, the generator voltage will rise as the train speed increases, and as the generator voltage rises the field current will also increase, causing a still further increase of voltage. As the train speed goes higher and higher a point will soon be reached where the field current rises above the capacity of the field fuse, causing it to blow.

IMPORTANCE OF OPERATING LAMPS AT THE PROPER EFFICIENCY.

The General Electric Company has recently issued Bulletin No. A4142, which deals minutely with the various operating conditions which affect the efficiency and life of incandescent lamps. The subject is treated exhaustively and is prefixed by an explanation of definitions, so that the context may be entirely clear. Thereafter, the advantages to the railroad of maintaining high efficiency in the operation of incandescent lamps are analyzed, and curves showing the effects of variations in candle-power, wattage, and voltage, are included in this section.

The bulletin is well illustrated and will enable the reader to obtain a working knowledge of all the conditions affecting the efficiency of incandescent lamps, and should be of considerable value to the illuminating engineer, central station, sales agent, and the customer.

RECEIVER APPOINTED FOR STANDARD ROLLER BEARING CO.

An application was made Oct. 22 to the United States District Court for the appointment of Receivers of the Standard Roller Bearing Company. The Court in this District appointed Robert S. Woodward, Jr., former president of the concern, and S. Laurence Bodine as Receivers, and decreed a bond in the sum of $100,000. The bill stated that the assets of the company, if properly conserved, were largely in excess of its liabilities.

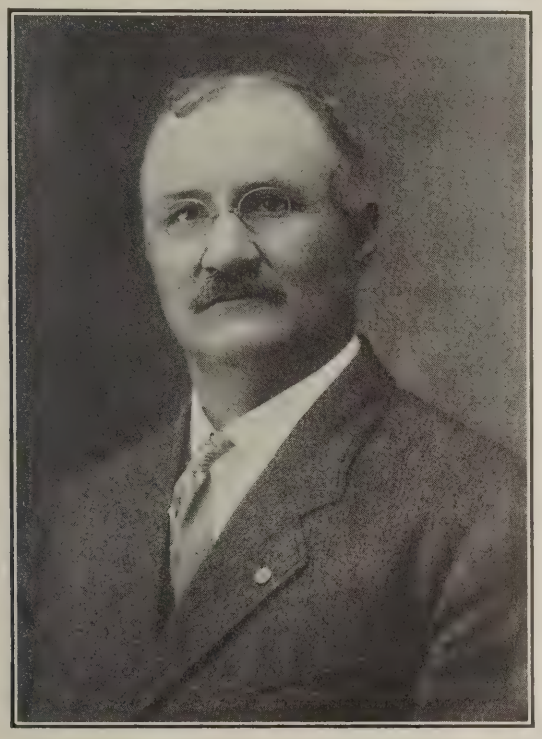
The Receivers will continue operating in the manufacture of steel balls, ball bearings, roller bearings and Rudge-Whitworth wire wheels for automobiles. Orders will be received and executed as heretofore. The existing organization will be preserved and the same high quality of product maintained.

General News and Personal Mention

G. M. CROWNOVER.

G. M. Crownover has been appointed Superintendent of Motive Power of the Chicago Great Western, with office at Oelwein Shops, Oelwein, Ia., succeeding J. G. Neuffer, resigned to retire from railroad service.

Mr. Crownover was formerly shop master mechanic at Oelwein. He was born at McVeyton, Pa., Sept. 26, 1863. He graduated from the high school at Hampton, Ia., and entered the service of the Illinois Central at



Mr. G. M. Crownover

Waterloo, April 1, 1881 as machinist apprentice and served four years, after which he worked two years as journeyman machinist. April 1, 1887 he was transferred to Clinton, Ill., as roundhouse foreman, remaining in this position until April 1, 1892, at which time he was transferred back to Waterloo, Ia., to take a position as machine shop foreman. In October, 1896, he was promoted to General Foreman in charge of the Waterloo shops. December 1, 1900, he was transferred to Fort Dodge, Ia., as division foreman and remained there until April, 1, 1902; then he took a position at Waterloo in charge of the new shops, as general foreman. November 20, 1902 he was appointed Master Mechanic at Freeport, Ill., and on November 15, 1904, was appointed shop superintendent in charge of Burnside shops, Chicago, Ill. On December 20, 1909 he resigned to accept a position as master mechanic for the Chicago Great Western at Oelwein, Ia., and he was appointed Supt. of Motive Power of that road Sept. 1, 1913.

NEW NATIONAL X-RAY CATALOGUE.

The entire line of "Eye Comfort" fixtures for indirect lighting is shown in catalogue "C." Both Metal and Compone fixtures have been redesigned; all canopies made to conform to design of bowl; style of chains, quality and variety of finishes have been improved. Several new fixtures, never before catalogued, are shown.

WARREN M. BEARDSLEE.

Mr. Warren M. Beardslee, general electrician of the Grand Rapids and Indiana, died October 14th, at his home in Grand Rapids, after an illness of but a few hours. His death was due to acute indigestion and lung infection. Mr. Beardslee was 37 years old and has for a number of years been associated with car lighting work. He is survived by wife and one daughter, and a sister and brother in Detroit.

C. A. EGGERT, APPOINTED SALES ENGR., RY. UTILITY CO.

Mr. Chas. A. Eggert has just been appointed Sales Engineer of the Railway Utility Co. with headquarters at Chicago. Mr. Eggert has been with the Consolidated Car Heating Co. for the past twelve years and has a wide acquaintance in the electric and steam railway field.

C. C. BRADFORD.

Mr. C. C. Bradford, formerly Manager of the Cleveland Branch Office of The U. S. Light & Heating Co., has been appointed Sales Manager of this Company, with offices at 30 Church St., New York City.

Mr. Bradford became identified with The U. S. Light

Mr. C. C. Bradford

& Heating Co. in 1909. After one year as Manager of the New York Branch Office, he went to Cleveland for the purpose of establishing a branch office in that city. His appointment to Sales Manager comes after three highly successful years as Manager of the Cleveland Office.

Mr. R. B. Clark has been appointed Acting Manager of the Cleveland Branch Office of The U. S. Light & Heating Co., Manufacturers of U-S-L Storage Batteries, Electric Starter and Lighter and Electric Train Lighting Equipments. Mr. Clark succeeds Mr. C. C. Bradford, who is now Sales Manager of this Company.

Private office of R. Creelman, Gen. Pass. Agt. Canadian Northern Railway, Winnipeg, Canada.

Eye Comfort Lighting
Increases Office Efficiency

The value of the Eye Comfort Lighting System in adding efficiency to railroad offices is proved by its unqualified endorsement of some of the greatest railroad systems in America. Some of the best railroad systems in the United States and Canada including Pennsylvania Lines, Frisco Lines, Union Pacific, Grand Trunk, and Canadian Northern have offices equipped with the

Eye Comfort
Lighting System

With Eye Comfort Lighting there are no glares or harsh shadows. The lights are not exposed but are concealed in opaque X-Ray Eye Comfort Reflectors, which are contained in the opaque fixture bowl.

Eye Comfort Lighting is soft, restful to the eye and unobtrusive. It will greatly increase the working efficiency of your offices.

Write us about your lighting problems

Our engineering department is experienced in planning lighting systems for railway offices. It can solve your most difficult lighting problem for you with Eye Comfort Lighting System—improve your office working conditions and save you much time and trouble.

Write us about your specific needs—or send today for our book "Correct Practice in Control of Light." It fully explains the Eye Comfort Lighting System.

National X-Ray Reflector Co.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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The Safety of Electric Locomotives

Consider for a moment the great tresses set up in the ordinary steel rail when a modern high power locomotive passes over it, hauling a heavy train at high speed; the grinding strain of a 10,000-lb. thrust from each locomotive driver which is distributed over little more than a line contact across the rail head, and at one instant is a tensile stress and the next instant one of compression, combined with which is a vertical load of three times this amount as well as a dynamic side thrust which when the train is operating at a high speed may reach almost unbelievable values. It is hardly surprising that many of the recent railroad wrecks have been assigned the rail failures.

Every practical railroad man knows that when a dead engine is hauled over a division there are usually some road-bed troubles develop shortly after. This undoubtedly is due to the pounding of the locomotive reciprocating parts which are then running dead.

The modern high speed electric locomotive has its load well distributed through its entire length and every wheel is a drive wheel. There can be no doubt that with the elimination of the reciprocating parts and variable strains of the steam locomotive, the electric locomotive which delivers a uniform torque with a minimum of rail pounding, will reduce rail failures with their very disastrous consequences.

"Safety first" is the slogan of all the railroads today. This is inspired partly by humanitarian motives and partly by those of financial considerations. From the standpoint of safety alone there is a good reason for very serious consideration of the subject of electrification of our main line divisions; but in the light of the excellent results from systems already in operation in which not only service and traffic considerations favor electric traction, but simple economy of operation, as well, the greater safety of the electric locomotive should be a deciding argument.

Reflector Maintenance

There is probably no class of service in which reflectors of a lighting system are subjected to greater deterioration, due to the collection of dust and smoke, than is generally found in railroad service. It is gratifying to note, however, that with the more general appreciation by railroads of the importance of illumination in general, and of proper distribution and efficiency in particular, there has come an awakening on their part to the fact that reflectors must be kept clean. It has been shown from data published in the *Railway Electrical Engineer* from time to time, that the depreciation in illumination can easily become as high as 30 per cent in three weeks if the reflectors are not kept clean, and steadily increases thereafter until reflectors are cleaned. Accordingly, the ease with which reflectors may be cleaned becomes of special interest to the railroad electrician who is directly in charge of this equipment.

Porcelain enameled reflectors have generally been preferred for this service, mainly because of their easy cleaning qualities; on the other hand, some offered an objection to the aluminumized metal reflector, which gave such excellent results in the recent B. & O. postal car lighting tests, in that its cleaning qualities were poor. We now find, however, that this type of reflector is made with a transparent coating which combines the excellent illuminating qualities of the aluminumized metal reflector and excellent cleaning qualities of the porcelain eanameled reflector.

All of these things, while they might be considered of a commercial nature, have a direct and very important bearing upon the lighting service in railway operation. In postal car service the railroads are, in effect, under penalty to provide proper and adequate illumination; but even in railroad shop lighting, proper and efficient illumination is very important. Take for example, the lighting of a single machine, the best reflector for the purpose may cost 80c while the machine may be worth several thousand dollars; so it is readily seen that the cost of the lighting unit, which must certainly be considered as an important part of the complete installation, forms an insignificant part of the total cost. Or, on the other hand, consider the value of the workman's time; even the loss of 2 or 3 moments' time in a whole day, due to eye strain caused by glare from bare lamps or insufficient illumination, would in a short time far more than offset the cost of the best reflector obtainable. Or again, considering it from the standpoint of the value of the work done, it will be self-evident that a proper system of illumination will pay big dividends.

But having that proper system of illumination—keep it clean.

Illumination of Street Railway Cars

At the November meeting of the Chicago section of the Illuminating Engineering Society, Mr. L. C. Porter and V. L. Staley delivered a paper on the subject of "Illumination of Street Cars." The authors pointed out that at certain rush hours there is a great drop in voltage, due to the heavy load, which with the carbon lamps, produces a marked decrease in illumination. This condition is serious, particularly in view of the number of customers being served, but the railroad companies do not feel justified in going to the expense of installing additional feeder capacity simply to provide better illumination. These factors, together with the rising standard of all illumination, makes it necessary that the street railway companies consider the matter of the installation of an efficient lighting system in their cars.

In some experimental cars, tungsten lamps, which are more efficient and less affected by voltage fluctuations, have replaced carbon lamps and high grade reflectors have been used to provide proper distribution and high efficiency of the lighting system.

A special shade holder has been employed which is made up of a split cone, which tightly grips the neck of the shade when the follower is screwed down; this is almost identical with that employed in steam road practice. The authors pointed out that reflectors should be of sufficient depth to prevent the lamp filament from being visible to any except the passenger almost directly beneath the lighting unit. When any system of semi-indirect or indirect lighting is employed the ceilings usually have a matte surface. If a glossy surface is used the direct reflection of the lamp filaments from this surface will cause an objectionable glare. The question of color of the interior finish of a car is one which warrants a great deal more attention than has been given it.

Whether the system of lighting be indirect, semi-indirect, or direct, the finish of the car has a very appreciable effect, not only on the illuminating efficiency of the system, but upon the passengers' comfort, as the light color finish gives a cheerful appearance and minimizes the sharp contrast between brilliancy of light sources and the surroundings. Tests have shown that with common dark yellow finish of street cars the efficiency of light utilization is approximately 15 per cent when no reflectors are used, and

A 34-Ft. Car Equipped With 21 64-Watt Bare Carbon Lamps.

30 per cent with a good direct reflector system. In one car in which the finish of the walls and ceiling was pure white, as high as 60 per cent efficiency has been obtained.

As to the types of lamps employed in this service, the author stated that four tungsten lamps have been especially developed for railway service, as follows:

TABLE I.

Railway company	Size of car body	Interior finish of car body	Lamps used in car body	Average foot-candles on 3-ft. horizontal plane	Lumens per sq. ft. in car body	Effective lumens per watt in car body	Total watts on car for lighting, body, platform and signs	Cost of illumination† at car at 1c. per kw-hr.
Mass. & Northern St. Rwy. Co., Athol, Mass.	*A* 8′ x 24′	Light mahogany and bird's eye maple headlining	10 64-watt carbon	4.0	8.58	1.3	960	$0.01135
	B 8′ x 24′	Dark green	5 56-watt tungsten with clear prismatic reflector	4.0	11.48	2.9	560	0.00935
Bay State St. Ry. Co., Boston, Mass.	*C* 8′ x 34′	Dark yellow	15 64-watt carbon	1.5	9.15	0.4	1,600	0.01892
	D 8′ x 34′	Dark yellow	6 56-watt tungsten with clear prismatic reflector	2.9	10.25	2.4	560	0.00935
Capitol Trac. Co., Washington, D. C.	*E* 8′ x 28′	Mahogany olive; green headlining	11 54-watt gem with flat steel porcelain enamel reflector	3.2	9.2	1.2	810	0.01060
	F 8′ x 28′	Mahogany olive; green headlining	8 36-watt tungsten with clear prismatic reflector	5.2	9.5	4.0	360	0.00652
Cleveland Rwys., Cleveland, Ohio	*G* 8′ x 34′*	Dark yellow	4 94-watt with alba reflector	37″ plane 4.2	11.3	3.4	585	0.01064
Bklyn. Rapid Tr. Co., Brooklyn, N. Y.	*H* 8′ x 28′	Dark yellow	14 23-watt tungsten	2.2	10.6	1.53	460	0.01043
	I 8′ x 42′	Red; white headlining	15 23-watt tungsten	42″ plane 2.7	7.6	2.6	460	0.01043

Data furnished by Macbeth-Evans Glass Co., Pittsburgh, Pa.

Lumens per watt:

64-watt carbon	2.6
23-watt tungsten	7.4
36-watt tungsten	7.4
56-watt tungsten	8.17
94-watt tungsten	8.17
54-watt gem	3.46

†List prices of lamps:

64-watt carbon	14c.
23-watt tungsten	35c.
36-watt tungsten	35c.
56-watt tungsten	45c.
94-watt tungsten	80c
54-watt gem	20c.

23-watt S-19 bulb operating at 1.34 watts per candle
36-watt S-19 bulb operating at 1.34 watts per candle
56-watt S-21 bulb operating at 1.20 watts per candle
94-watt S-24½ bulb operating at 1.20 watts per candle

All four types are giving a laboratory life of 2,000 hours and are so rated in the manufacturer's data book. This life under service conditions may be estimated at 1,200 to 1,500 actual burning hours. From these figures it is easy to see that these lamps are economical.

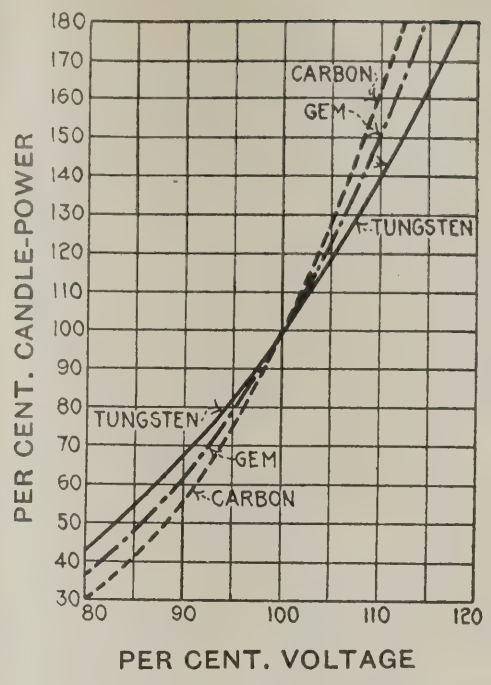
A 34-Ft. Car Lighted With 56-Watt Tungsten Lamps, Equipped With Prismatic Reflectors.

If ten 56-watt tungsten lamps and reflectors are used the saving becomes $0.0096 per car hour, while the useful illumination is practically doubled. This saving in 1,466 hours' operation would pay for the eight reflectors and eight special holders necessary. Thus, after five months' operation (at ten hours per night) the equipment will have paid for itself, and from then on a clear saving of $0.0096 per hour would accrue to the company, to say nothing of the advertising value of well lighted cars.

Tests.

It may be of value to give a brief summary of tests conducted on typical types of cars and typical lighting equipment. In Table I tests *A* and *B* were made on ordinary small cars, *A* being lighted by the not uncommon systems of grouping 64-watt carbon lamps on the center deck. In car *A* there were four lamps in the center of the car, two lamps located four feet to each side of the center and one at each end. This resulted in very uneven illumination, there being a maximum of 9.75 foot-candes in the center of the car, which fell to 1.5 at the ends. Car *B* was a similar car, lighted with five 56-watt tungsten lamps and clear prismatic reflectors in the car body. The illumination in this car was very uniform, having a value of 6.5 foot-candles in the center and 2.25 at the extreme ends. This was obtained with a considerable power saving and a large reduction in glare.

Cars *C* and *D* were typical 34-foot cars, *C* being lighted with fifteen 64-watt carbon lamps in the car body and car *D* with six 56-watt tungsten lamps equipped with clear prismatic reflectors. Comparison of these two cars shows that the average illumination



Curves Showing Variation in Candlepower Due to Voltage Variation, for Carbon, Gem and Tungsten Lamps.

in the car *D* is considerably greater than that of the car with carbon lamps; that the effective lumens per watt vary by so great a difference as 0.4 to 2.4 in favor of the tungsten lamps; also that glare was practically eliminated in car *D*.

Car *E* is a typical 28-foot car lighted with gem lamps grouped under flat steel porcelain enamel reflectors, while car *F* is a similar car lighted with two rows of 36-watt tungsten lamps equipped with clear prismatic reflectors on the center deck. In this car transparent signs are used, which depend entirely on the interior light of the car for their illumination. It will be seen that this car has a considerably higher average intensity which, due to the absence of glare, gives an effective illumination even higher than the intensity values indicate, as no photometer will measure the effect of glare.

Car *G* is a 34-foot car similar to car *B*, but in which the carbon lamps have been replaced by one circuit of 94-watt tungsten lamps equipped with alba reflectors, four being located in the car body and one on each platform. In addition to these there is one circuit of 23-watt lamps for signs and headlight. The distribution curves show that the illumination in this car, while of excellent intensity and quality, is not quite so uniform as was obtained with the 56-watt system in car *D*. This is due to the necessarily long spacing, where but four lamps are used in a 34-foot body.

Car *H* is a typical 28-foot car in which the old carbon lamps have been replaced, lamp for lamp, by 23-watt clear bare tungsten lamps.

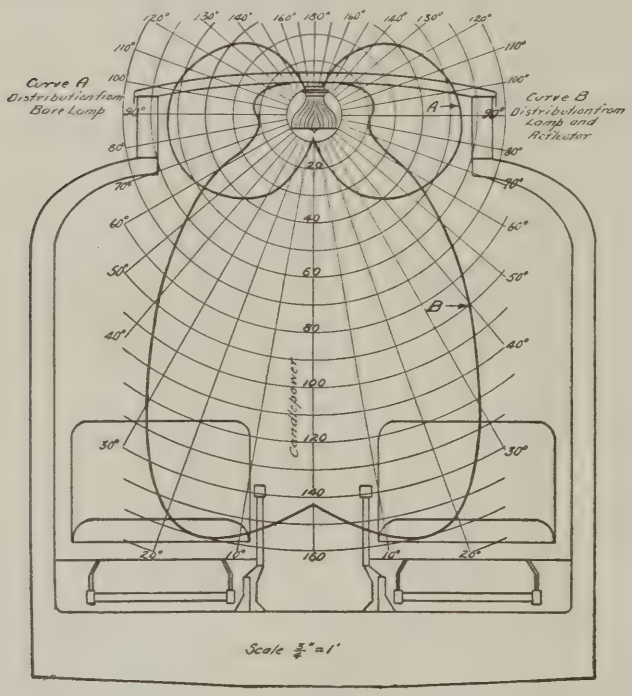
Car *I* shows well the enormous advantage of white headlining. In this car, though lighted with semi-indirect fixtures the average illumination with but 23 watts higher power consumption is equal to that of car *H* (readings taken on a 42-inch plane are accordingly higher than on a 36-inch plane). This is due to the dark yellow ceiling of car *H* and the white porcelain enamel of car *I*. After these two cars have been in service for some time the depreciation in car *I* will undoubtedly be considerably higher than in car *H*.

It may be apropos, where so much stress has been laid on the question of glare, to call attention to the

fact that the more light thrown directly in the eyes of an entering passenger the more brightly illuminated will the car appear. To an outside observer or an entering passenger, at first glance the car lighted with properly diffused light will appear darker than one lighted with clear, bare lamps, though the former may actually deliver far more light on the reading plane, where it is of service. A few moments' reading in such a car makes its comfort over the glary one very apparent.

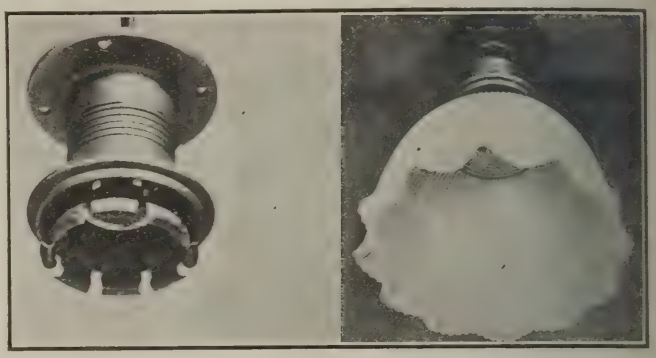
Methods of Test.

In making photometer tests in street cars readings are generally taken on a horizontal plane 36 inches above the floor. The width of the car is divided into

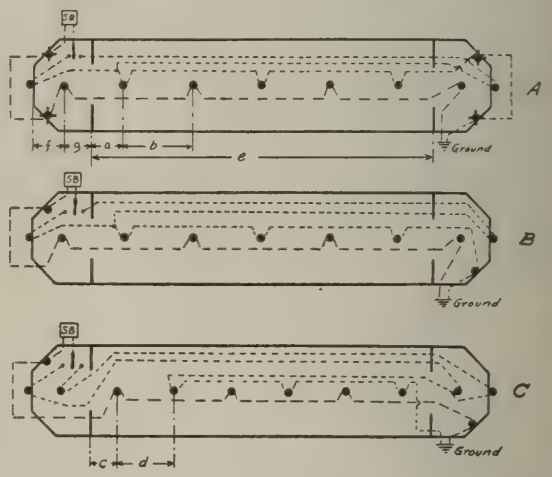


Light Distribution From a Clear Bare 56-Watt Railway Tungsten Lamp, and From the Same Lamp Equipped With an Intensive 40-Watt Clear Prismatic Reflector.

5 parts and a line of stations run through the center of each division; thus in an eight-foot car one line of stations would be directly down the center of the car, the next 19 inches towards the side of the car and the third 38 inches from the center line. Along these lines stations are chosen over the forward edges of the cross seats. Their location gives the average positions in which passengers hold their reading matter. Where long seats are used the stations are generally taken every two feet lengthwise in the car. Due to the fluctuating voltage of a trolley circuit it is necessary to take simultaneous voltage readings with photometer readings. In order to make one test comparable with another, each photometer reading must be corrected for voltage to the normal voltage of the lamps used.



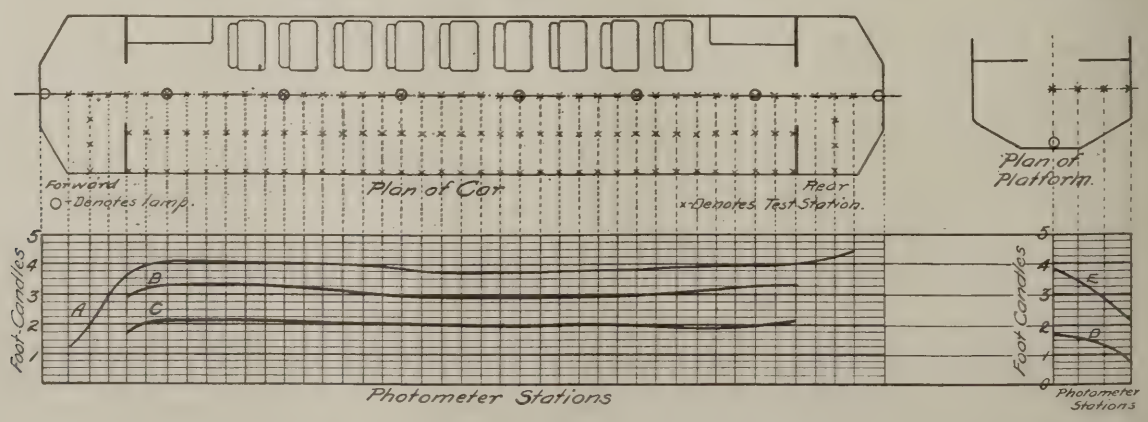
Special Shade Holder Designed for Railway Cars. Same Equipped With a Reflector.



*A- Car wired for burning both platform lamps and two markers on each platform. 5 lamps in car body.
*B- Car wired for burning both platform lamps and one marker on each platform. 5 lamps in car body.
C - Car wired for burning rear platform lamp only. 6 lamps in car body.
● - Denotes a 56 W. Railway Mazda Lamp. Full Voltage
✚ - Denotes a 28 W. Railway Mazda Lamp. Half Voltage

Spacing	Length of Interior of Car Body "e"						
	e-28ft	e-30ft	e-32ft	e-34ft	e-36ft	e-38ft	e-40ft
a	2 "	3 "	2 "	3 "	*2½"	*3½"	*2 "
b	6 "	6 "	7 "	7 "	*3½"	*3½"	*4 "
c	1½"	2½"	2½"	2 "	3 "	2½"	2½"
d	5 "	5 "	5½	6 "	6 "	6½"	7 "
f = g	in all cases where practical						

Wiring Diagram for Trolley Cars.



Graphical Results of Illumination Test of Car Equipped With 8 56-Watt Tungsten Lamps and Prismatic Reflectors.

Usually five readings are taken at each photometer station. In some instances, particularly where relatively great spacing of the lighting units is in use, it is of value to take readings on 45-degree planes towards each end. The ratio of these readings multiplied by the horizontal values gives an arbitrary measure of the relative effectiveness of the lighting system.

In order to obtain figures on the cost of operation of different systems which may be applied to any road the authors submit Table II, figured on the assumption that energy delivered at the car costs 1 cent per kilowatt hour and that lamps are purchased on a $1,200 contract and have a service life of 1,200 hours. The resultant figure shows the cost of lamp renewals plus the cost of energy per lamp per hour. By multiplying the resultant figure thus obtained, *i. e.*, cost per lamp per hour by the number of lamps per car by the number of cars in service by the total car hours of illumination per year, a figure showing the cost of illumination per year is easily obtainable. In figuring the car hours of illumination, account should be taken of the percentage of total cars in service which operate all night and those which operate three-fourths, one-half or one-fourth of the night, etc. The lighting hours vary throughout the year, but an average of ten hours per night is a conservative figure covering all night burning the entire year round.

TABLE II.

Lamps.	Cost of renewals per hr. (1,200 hrs. life). $1,200 basis.	Cost of power per hr. at 1c. per kw.-hr.	Total operating cost, *i. e.*, renewals and energy per lamp per hr.
64-watt carbon	$0.00008	$0.00064	$0.00072
23-watt tungsten	0.00021	0.00023	0.00044
36-watt tungsten	0.00021	0.00036	0.00057
56-watt tungsten	0.00027	0.00056	0.00083
94-watt tungsten	0.00048	0.00094	0.00142

No figures have been given for the cost of cleaning and maintenance of reflectors, where reflectors are used, as the authors were unable to find any accurate data on this subject.

Summary.

The use of tungsten lamps in place of carbon is highly advantageous because they produce better illumination at an actual saving in operating expense. Where tungsten lamps are used it is highly desirable to install efficient reflecting devices to reduce glare and increase the efficiency of light utilization. In all cases a light interior car finish is to be desired.

New Electric Locomotives for the New York Central Terminal

The New York Central & Hudson River R. R. Co. has recently ordered six additional powerful, passenger, electric locomotives from the General Electric Company for terminal service out of New York City. Early in the year ten electric locomotives of the most powerful type ever built were ordered from this company for the same service. These engines weigh 100 tons each. While the new machines are of the same type and construction, they are somewhat heavier, weighing 110 tons, and due to recent advancement in locomotive design, have materially increased capacity for continuous service.

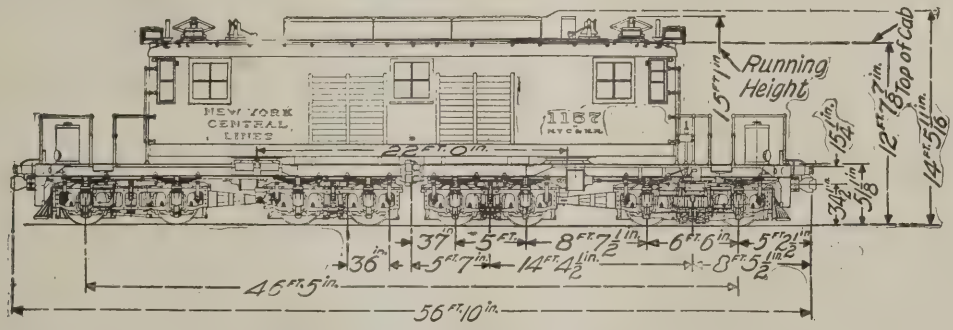


Diagram of New High Speed Electric Locomotive. Every Wheel Is a Drive Wheel and the Weight Is Well Distributed so as to Reduce Road-Bed Stresses to a Minimum.

The growth in traffic and the corresponding increase in the demand for larger and heavier train units since the introduction of electric locomotives in the New York Central Terminal has been indeed notable. In 1906 thirty-five 600 volt, direct current, passenger, electric locomotives were built by the General Electric Company and introduced in the terminal. These machines are of the 115-ton, 4-8-4 type and are each equipped with four GE-84 bipolar, gearless motors. Twelve more engines of the same type were placed in service in 1908. All these locomotives were designed with sufficient tractive effort to operate 535-ton gross weight trains at 60 miles per hour in the regular terminal service.

The ten 100-ton electric locomotives ordered the fore part of this year are designated type 4-4-4-4 and are each equipped with eight GE-89 bipolar, gearless motors, all the weight of the machine being carried on motor-driven ales. These engines are designed for pulling the heavy limited trains and will exert sufficient tractive effort to operate 800-ton trains in continual service between the New York Central Terminal station and Harmon. They are capable of operating a 1,000-ton train in emergency service or a train of the same gross weight on level tangent track continuously, at 60 miles per hour, or an 800-ton train at 65 miles per hour.

But the weight of trains which are being hauled out of the Terminal is ever increasing steadily, and some of the more important trains now weigh over 1,000 tons. It has therefore been deemed desirable to have engines for the maximum service with very great continuous capacity, ample overload and high momentary rating. The new locomotives are able to exert practically the same tractive effort continuously that the previous ten locomotives can for one hour.

The ten tons' increase in weight in these machines is accounted for mainly by the greater amount of material in the motors, which are of larger capacity. The speed and torque characteristics of the locomotive

have been kept practically the same as those of the former ten machines, but the new locomotives are capable of hauling approximately 40 per cent. greater tonnage in continuous service.

The previous ten 100-ton locomotives have a capacity for developing 1,460 horsepower continuously, 2,000 horsepower for one hour and can develop as high as 5,000 horsepower for short periods. This corresponds to a tractive effort of 9,000 pounds at 60 miles per hour continuously, or 13,500 pounds at 54 miles per hour at the one hour rating. The six new electric engines will develop 2,000 horsepower continuously, or 2,600 horsepower for one hour. The equivalent tractive effort is 14,000 pounds at 54 miles per hour continuously, or 20,000 pounds at 49 miles per hour at the one hour rating. They are able to haul 1,100-ton trains in continual service between the Terminal and Harmon, are capable of operating 1,200 ton-trains in emergency service, and 1,200-ton trains on level tangent track continuously at 60 miles per hour.

In point of design and construction the new machines will be of identically the same type as the former ten engines, having an articulated frame with bogie guiding trucks at each end. The cab containing the engineer's compartment and that for the operating mechanism is swung between the two parts of the frame on center pins. Each section is equipped with two-axle trucks having a driving motor mounted on each axle. All the axles are, therefore, driving axles; and the eight motors, of the bipolar gearless type, are of the same general design as the motors on all the previous 57 locomotives, and are provided with ample forced air ventilation.

The motors are electrically connected permanently in parallel in pairs and the pairs can be connected in three combinations; viz., series, series-parallel and parallel. They are insulated for 1,200 volts, so that if at any future time it should be desired to operate the locomotive on this voltage, the pairs of motors could be changed from parallel to series connections and the same speeds and control combinations obtained as on 600 volts.

The new locomotives are now under construction in the works of the General Electric Company at Schenectady, N. Y., and will be placed in operation as soon as completed. Compared with existing types of electric engines, these machines have greater capacity and higher efficiency than any other high speed electric locomotive ever constructed. Withal, the total weight, weight per driving axle and "dead weight" is less than that of any other locomotive of their capacity.

Effective Dining Car Illumination

Recently a number of new dining cars have been put into service on the Rock Island Lines, the lighting equipment of which represents such a marked advance in railroad car lighting as to require special comment and description.

The principle applied in planning this lighting equipment apparently has been, "Conceal the primary light source." Fig. 1 shows how successfully this has been acomplished, for no lamps whatever are visible to the eye. Apparently the entire illumination in the car is supplied by the center deck indirect lighting units, but a closer inspection of the illustration will reveal a small glass panel in the half deck over each table. This is the bottom plate of a prismatic reflector plate type of unit. Thus we have superimposed on the indirect illumination of the car, this additional direct illumination for each table.

The indirect illumination is ideal for the general illumination of the car, as its diffuse and uniform character makes it very comfortable and aids vision materially in that all glare of exposed light sources is eliminated. The localized direct illumination gives the desirable sparkle to the cut glass and silver, which is noticeably absent with entirely indirect illumination, due to its extreme diffuseness. The side-deck direct illumination, however, is so well shielded and the eye so well protected from it, that it causes no noticeable discomfort.

This unit has been designed particularly for semi-concealed lighting of passenger cars and the bottom prism plate is designed so as to give an assymmetrical distribution of the light, the maximum illumination being directed slightly at an angle toward the center of the car so that the amount of light lost on the side walls is low.

Some of the details of construction of the indirect lighting unit will be of interest. The bowl proper is of cast iron enameled with a decorative design, and this is supported by four rigid bars cast in the form of a square chain. A 50-watt lamp is mounted inside of an E-100 silvered glass reflector, which is supported by a special holder shown diametrically in Fig. 6.

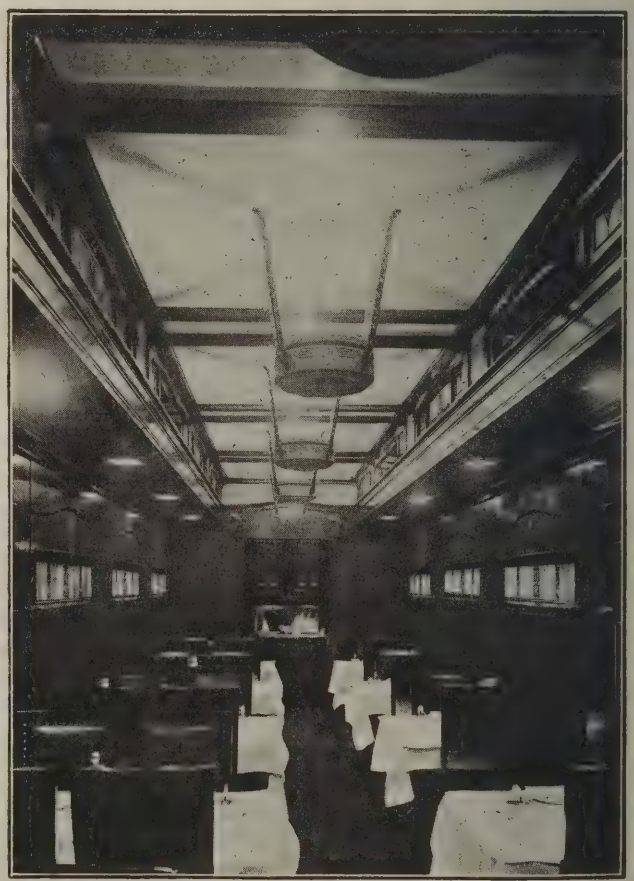


Fig. 1. Night View of Diner With No Other Illumination Than That of the Lighting System. Main Illumination Is Provided by the Indirect Lighting Units in the Center of the Car, But There Is a Concealed Light With Reflector in the Half Deck Over Each Table.

From the illumination curves, Fig. 3, it will be noted that the illumination in this car is very uniform, indeed. Although some might consider this hardly of sufficient intensity, the wattage as now used in the car is low, there being but five 50 watt and ten 15 watt units, a total of 400 watts in the diner. If it is found desirable, this can easily be raised by using 80 watt lamps in the center deck indirect fixtures and 25 watt lamps in the direct lighting units in the side deck.

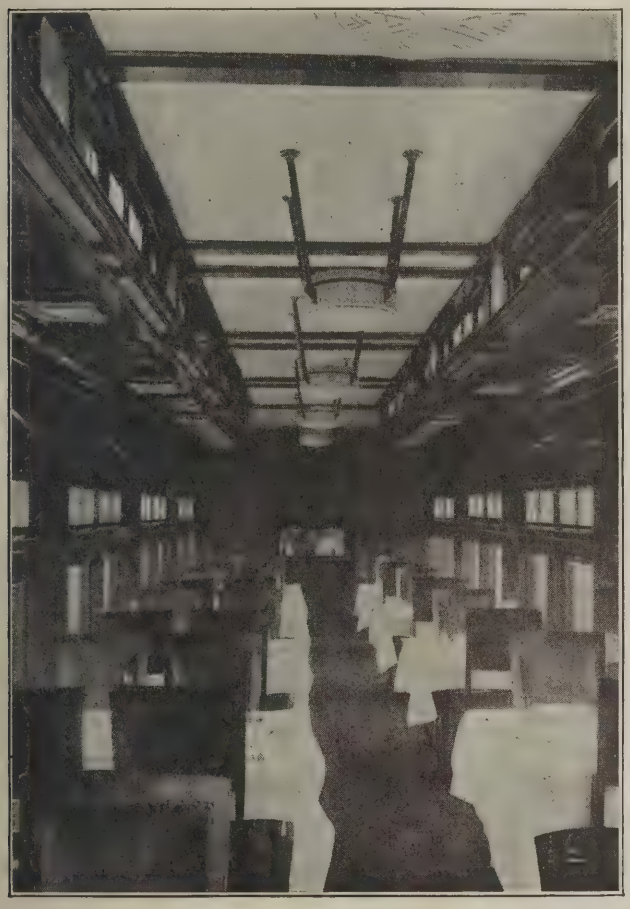


Fig. 2. View of Diner in the Daytime.

The general appearance of the car is excellent, there being no direct light or glare from the lighting units to cause eye strain.

On the floor plan of the car, Fig. 4, is shown the location of the center deck indirect units, and also the side deck direct units. The indirect units are equipped

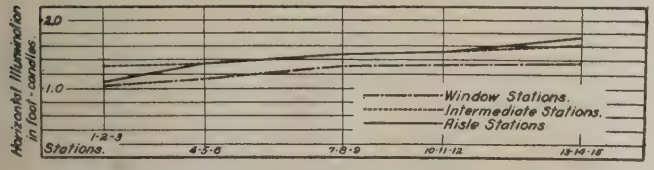


Fig. 3. Graphical Results of Illumination Test, Showing the Illumination in One-half of the Car Only.

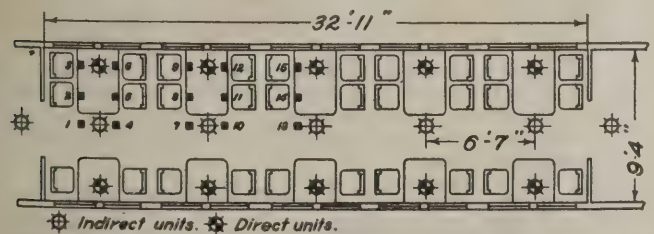


Fig. 4. Plan View of Diner, Showing the Location of Lamps and Test Stations.

Fig. 5. View of Indirect Lighting Fixture. The Bowl Is Entirely Opaque, All Light Being Directed Upward to the Ceiling by the Reflector Within.

with 50-watt, 32-volt tungsten train lighting lamps and one-piece silvered glass indirect lighting reflectors, as shown in Fig. 6. The direct units are equipped with 15-watt, 32-volt tungsten lamps in prismatic reflectors having a flat bottom prism plate.

It will be noted that the ceiling of these cars has a decidedly glossy finish. Apparently this does not

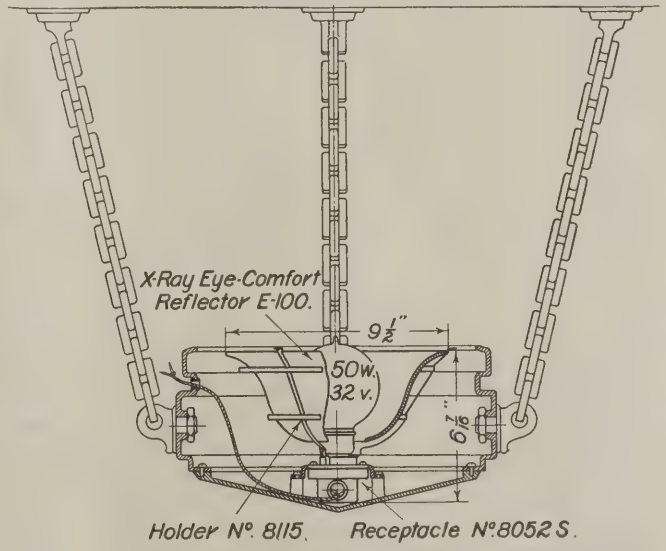


Fig. 6. Detail View of Reflector With Part Cut Away to Show Location of Reflector and Lamp.

greatly alter the uniformity and diffusion of the resultant, but it is a well recognized fact that a matte surface gives more ideal results. The finish may be smooth, but should preferably be rubbed down to make it semi-dull. This will avoid the probability of seeing a blurred reflection of the lamp and reflector in the ceiling.

The fixtures, both indirect and direct, were furnished by the Safety Car Heating & Lighting Co., silvered glass National X-Ray reflectors being used in the indirect fixtures and Holophane prismatic reflectors and plates in the direct lighting fixtures.

Electrification of Railways

PROFESSOR GISBERT KAPP

Editor's Note—At the recent meeting of the British Association for the Advancement of Science, at which Sir Oliver Lodge delivered his already famous address on "Continuity," numerous other addresses were presented by the presidents of the various sections. The address of Professor Gisbert Kapp, president of the engineering section, was devoted very largely to the discussion of the electrification of railways. His address contains much valuable information which will be of special interest to our readers, in fact, it is about the most comprehensive statement of the situation ever made, so instead of abstracting this paper, we are publishing it in almost complete form.

(Continued from Last Month.)

Motor Design

The number of patented designs for single-phase traction motors is very large; but, notwithstanding considerable difference in matters of detail, all motors which have been successfully applied in practice may be ranged under three great groups—namely, the so-called repulsion type, the repulsion type with additional excitation of the rotor, and the straightforward series motor. The present tendency is rather in favor of the series motor, and the practical results obtained with it are certainly very promising. The latest design made by Dr. Behn-Eschenburg shows a remarkable weight efficiency. His 2,500 horsepower electromotives (the power being at a one and a half-hour rating) weigh only 108 tons, so that at this rating 1 horsepower is obtained with a total weight of 43 kilogrammes. This compares favorably with the high-pressure C. C. system, where 50 to 70 kilogrammes per horsepower may be taken as normal values.

The so-called "repulsion motor" invented by Professor Elihu Thomson has been applied to railway work in the slightly modified form due to Mr. Deri, where, instead of there being only two brushes per pair of poles, double the number is provided, and the adjustment for speed and torque is made more accurate, whilst at the same time the commutation, being split up into two steps, becomes easier. In the matter of simplicity, an electromotive fitted with Deri motors cannot be surpassed by any other arrangement. There are no rheostats, contactors, control switches, or other gear; all the regulation is effected by mechanical transmission of the movement of a hand wheel placed in the driver's cab to the brushes of the motors. At one time it was hoped that this system would win its way to a general application; but, unfortunately, the motor must run somewhere near synchronous speed, and becomes therefore rather heavy with the low frequencies alone possible in traction. Moreover, as the power-factor obtainable is only about 0.80, that is, considerably below the value obtainable with other motors, there does not seem to be any great future for this system for heavy work, although its great simplicity may still turn the balance in its favor on lines with a light traffic. For heavy lines the choice at present lies between the induction-motor with direct rotor excitation and the straightforward conduction-motor, where rotor and stator are traversed in series by the same current. The former type of motor—also called the Latour-Winter-Eichberg motor—depends for its working current in the rotor on electro-magnetic induction, which produces the working current in the rotor much in the same way as the current in the secondary circuit of a transformer is produced by induction. Since the motor has in part the character of a transformer its weight would, as is the case with any transformer, be unduly augmented by too great a reduction in the frequency. Experience has shown that a frequency of twenty-five periods per second is high enough to render the transformer action effective, and at the same time not so high as to introduce serious difficulties as regards e. m. f. of self-induction and commutation. This frequency has been adopted in most cases where electrification of main lines has been carried out by motors of this class. One valuable feature of this motor is that at a speed slightly exceeding synchronism the power-factor may be brought up to unity. At this speed the commutation takes place under contditions which may be described as theoretically perfect. A fair number of Continental lines have been electrified by using these motors, and they have also been adopted, with very satisfactory results, in the electrification of the London, Brighton and South Coast lines between Victoria and London Bridge and to some distance south of London. On this line no locomotives are used, but only motor coaches. It is therefore not possible to make a direct comparison as to weight efficiency with a locomotive. The latter has only to carry the propelling machinery, whilst the former has to provide accommodation for passengers as well. The 600 horsepower motor coaches on the Brighton line weigh 50 tons, or at the rate of 83 kilogrammes per horsepower. A 1,000 horsepower C. C electromotive taking current at 1,200 volts weighs 74 tons.[1] By making a suitable reduction for the extra weight of the passenger accommodation in the A. C. coach, its weight per horsepower comes out at something like 60 kilogrammes, against 62 kilogrammes in the C. C. engine.

Series motors are employed on the electrified lines of the Midland Company between Heysham, Morecambe, and Lancaster. Also in this case motor coaches, and not electromotives, are used. At the rour-rating a motor coach develops 420 horsepower, and as its total weight is about 35 tons, we have here the same weight-efficiency as on the Brighton lines—namely, 83 kilogrammes per horsepower for the whole coach.

High Voltage Direct Current Systems

Of high-pressure continuous-current lines there are many examples, both in Europe and America. The term high-pressure does, of course, not imply the same order of magnitude as in single-phase A. C. lines. There high-pressure may mean anything up to 15,000 volts, the pressure which is likely to become a standard in future electrifications; but in C. C. work one must class anything over 1,000 volts or 1,500 volts as high-pressure. The general rule is to employ motor coaches, and not electromotives; but there is a private line belonging to a steel-works in Lorraine, where two electromotives, each of 600 horsepower (four C. C. motors of 150 horsepower) are working the mineral trains under a pressure of 2,000 volts. The Southern Pacific Railway also employs C. C. electromotives of 1,000 horsepower each. Each engine weighs 74 tons, and hauls a train of 270 tons on grades of 40 per mille. This is a remarkable performance, rendered possible by the fact that with the even torque exerted by the electric motor a much larger co-efficient of friction than is possible in steam traction may safely be permitted. Electrical engineers generally base their cal-

[1] See Gratzemueller's paper read at the Paris meeting of the I. E. E. and S. Intern. des Electr. (Paris, May, 1913).

culation of the possible tractive effort on a co-efficient of 0.17, without sand, and as high as 0.25, or even 0.28 if sand is used. The voltage in the case of the Southern Pacific engines is only 1,200 volts, taken by two motors in series, and there is provision made to change over from the overhead wire to third rail, with 600 volts, when the motors are all in parallel. On European C. C. lines the voltage is higher—generally 2,000 volts, as on the Chur-Arosa and some other Swiss lines—and the tendency is still in the direction of higher pressures. Continental makers are now prepared to go as far as 1,200 volts per motor, so that with the usual system of series-parallel control a line-pressure of 2,400 volts becomes possible. The greatest step in advance in this direction has, however, been made in England, where Messrs. Dick Kerr, Ltd., have adopted a line-pressure of 3,500 volts as their standard, involving the use of motors constructed for 1,750 volts. After having experimented with this high-pressure system for two years, they have undertaken the electrification of a short section of the Lancashire and Yorkshire Railway with continuous current at 3,500 volts. I am indebted to the firm for the following particulars: The current is collected by pantograph from an overhead wire with catenary suspension. The train consists of a motor coach and two trailers. The motor coach is equipped with four 300 horsepower motors, and weighs 62 tons; the trailers weigh each 26 tons. From these figures it will be seen that the weight of the motor coach per horsepower is only 52 kilogrammes, and thus considerably below what the weight of an equivalent single-phase motor coach would be. It is especially the saving in weight and the avoidance of any telephonic disturbances which renders the C. C. system so attractive that, in spite of a natural reluctance against the use of high-pressure on a commutator, designers are giving increased attention to the use of continuous current for electric traction. The difficulties which some engineers anticipate with commutator and brushes seem, however, rather imaginary than real, if we may judge from the experience with the 3,500-volt motor coach. The makers inform me that they estimate the mileage for a set of carbon brushes at 50,000 miles. The motors drive the car-axles by single reduction gear, and are controlled by contactors operated from a master controller. The current for operating the contactors, driving the air-pump motor, and for the general service of lighting and heating is obtained fom a small motor-generator, fed on the primary side at 3,500 volts, and delivering C. C. at 210 volts. All motors have commutating poles—a practice which has become universal in C. C. traction work.

From the figures quoted above it will be seen that where motor coaches are employed the C. C. system has an advantage in point of weight over the single-phase A. C. system. But main-line traction, including goods trains, is not going to be done by motor coaches, and if we come to large electromotives of some 2,000 to 3,000 horsepower then this advantage is likely to vanish. No high-pressure C. C. electromotive has as yet been built for so large a power, and it is therefore not possible to make a direct comparison; but, if we may judge from the largest engines yet built for moderate-pressure C. C., there is little probability that the C. C. system for high-pressure can beat the single-phase system, and none whatever that it can beat the three-phase system.

Single Phase Systems

In the early days of single-phase traction some trouble has been experienced in the matter of telephonic disturbance. A systematic investigation carried on for over a year on the Seebach-Wettingen line, chiefly by means of the oscillograph, showed that this trouble was due, not as had originally been suspected, to the commutator, but to the employment of open slots in the rotor, and the trouble nearly ceased when new rotors with semi-closed and spiralled slots were used. To further improve the telephonic service the usual remedy of metallic return and drilling the telephone lines was employed. Although by these means it is possible to render telephonic speech over a line alongside a single-phase railway nearly, and perhaps quite, as clear as it is along a C. C. railway, there still remains the danger that the telephone lines may, by electrostatic induction, acquire a very high potential. The remedy against this danger, first applied on some Swedish experimental lines, is to short-circuit the two wires of each circuit by a choking coil of very high inductance, the center of which is earthed. The static charge is thus carried off to earth, whilst the telephonic currents are only inappreciably weakened.

One of the advantages possessed by the alternating over the continuous current is the simplicity of regulation. There are no contactors and no rheostats used, the power and speed of the motors being adjusted by the use of tappings on the secondary side of the transformers. As transformers are necessary in any case in order to work with a high voltage on the trolley, the introduction of tappings does not materially increase the weight, whilst at the same time it affects a great reduction in the primary starting current. The only difficulty that still remains is that of sparkless commutation, and inventors have evolved many, and sometimes very complicated, arrangements for overcoming it. As so often happens with engineering problems, the most simple solution is, after all, found to be the best in practice; and of all the ingenious inventions patented during the last ten years very little use is made by the designer of traction motors. Broadly speaking, only two methods are in use; the one is the method first made known by Messrs. Winter & Eichberg, where the working field is produced by direct excitation of the rotor and the transformer e. m. f. in the coils short-circuited by the main brushes is balanced by an e. m. f. of rotation due to a transverse field; and the other method applicable to the straightforward series motor, where a non-inductive shunt is connected to the terminals of the compensating or commutating winding. The effect of a non-inductive shunt is to make the armature field slightly leading over the field produced by the compensating winding. The resultant of these two fields is in position coincident with the brush axis, but has in point of time a phase difference of a quarter period over the working current, thus balancing the e. m. f. of self-induction which lags by a quarter period. Obviously this balancing effect can only take place when the motor is running, since it depends on the balance between an e. m. f. of self-induction which is independent of speed and an e. m. f. of rotation which is proportional to speed. At starting, when there is no speed, there is no compensation. Thus there would appear to be a new difficulty in the way of the use of single-phase current; but also this has been overcome in quite a simple manner. Experience has shown that a potential difference of 7 volts between heel and toe of brush, and a current density of 15 A. per sq. cm., is

permissible. If, then, we use narrow brushes, covering at any time not more than three segments, use coils of only one turn to each segment, and work at a reasonably low frequency, and not too high a total flux, it is possible to keep the transformer voltage and current density well within the above limits. This is not a severe limitation, for it enables the designer to use a flux out of one pole of 2.4 megalines if the frequency is 25, and 3.6 megalines if it is 15. The number of poles has then to be selected in accordance with the power desired. Obviously the lower periodicity is to be preferred, because the motor may be built with a lesser number of poles, and will then occupy less room—a matter of considerable importance, considering the limited space which is available in an electromotive. The frequency of 15 has also some other advantages over that of 25. The e. m. f. of self-induction is proportionately less, and, in consequence, the power-factor is about five per cent better. The skin effect in the rails is much reduced, and also disturbances on neighboring circuits which may be due to inductive or capacity effects. On the other hand, the generators become a little more expensive and the transformers on the electromotives a little heavier. But, notwithstanding these drawbacks, the balance of advantage is with the lower frequency, and that is the reason why the Commission of Experts called together in 1904 by the Swiss Government to establish standards for the electrification of the Swiss railways has decided that 15 shall be the standard frequency, with a tolerance down to 14, and up to 16 2-3. Since then other States have fallen into line, so that 15 is now the standard frequency nearly all over the continent of Europe. The standard pressure is likely to be 15,000 volts. For three-phase traction the standard pressure is 3,000 to 3,300 volts.

The subject of electric main-line traction is so vast that in the limited time at my disposal I have only been able to mention a few of the important features of this interesting problem. A detailed account of all that has been done in electrification would take far more time than we can spare; but, by way of example, I give below two tables referring to the Italian State Railways. I am indebted for the information to Mr. v. Kando, who may justly be described as the father of three-phase traction.

The most recent example of single-phase electrification is that of the Loetschberg line establishing direct communication between Berne and the Simplon line. I am indebted to Dr. Behn-Eschenburg, the designer of the electromotives, for the following information. The power at the one-and-a-half-hour rating is 2,500 horsepower, and the total weight of the engine is 108 tons, of which 85 tons is taken by the five driving axles. At the normal speed of 50 kilomètres per hour the tractive effort is 10 tons. This can be increased at starting to 18 tons. On the heaviest grade (27 per mille) the tractive effort is 13.5 tons, which suffices for a train of 310 tons. The maximum speed is 75 kilomètres per hour. There are two 1,250 horsepower motors on each engine. Each has its own transformer and controller, the principle of duplication being carried out in all the details, so that in the event of a defect to any one part the other remains serviceable. The potential difference between tappings is 45 volts, and the last step gives with 15,000 volts on the trolley 520 volts. This is in excess of what is required by the motor, and thus provides for the event that the trolley-voltage should for some reason fall below the standard pressure. The normal voltage of the motors is 420, and the full-load current 2,700 A. At starting on the level the line-current is about one-third of the full load-current, and the power ten per cent of the full power. When starting on an up-grade of 27 per mile with a train of 310 tons the current taken from the trolley is forty per cent of the normal full-power value, and the acceleration .05 mètres per second per second. The current is taken from the overhead trolley by two pantographs, the pressure being 15,000 volts, and the frequency 15. The controller drums are each worked by an electromotor and rocking pawls under the electric control of a master controller, so that the driver is relieved of any physical exertion in attending to the regulation of the motors. These have 16 poles, a compensating winding to increase the power-factor, and commutating poles shunted by a non-inductive resistance to insure sparkless collection. The power-factor is about 0.95 over a wide range of load. The motor is geared by double helical wheels (ratio 1:2.23) to a blind axle, from which the turning moment is transmitted to the drivers by cranks and connecting rods. The weights are as follows: Motor 11.8 tons; gear, 2 tons; transformer, 7.5 tons; and controller, 1 ton; total, 22.3 tons; or at the rate of 17.8 kilogrammes per horsepower on the one-and-a-half-hour rating. The total weight of the electromotive is at the rate of 43 kilogrammes at the same rating. This is a remarkably high weight-efficiency, which has up to the present not been reached by any continuous-current electromotive, and has only been surpassed by the three-phase 2,000 horsepower electromotives (taken at the one-hour rating) of the Italian State

Italian State Railways Electrified on the Three-phase System.

Location of Line	In Service			In Construction		
	Lecco Colico Sondrio Chiavenna	Campasso Pontelderimo Busalla	Bussoleno Bardonecchia Modone	Savona S. Giuseppe Ceva	Lecco Monza	Genova Sampierdarena Ronco
Length, in kilometres	107	19	58	45	38	28
Heaviest Grade per mille	22	35	30	25	12	17
Number of Transforming Stations	10	4	7	4	4	2
Transmission Voltage	20,000	13,000	59,000	62,000	25,000	57,000
Trolley Voltage	3,000	3,000	3,300	3,300	3,300	3,000
Frequency (cycles per second)	15	15	16⅔	16⅔	16⅔	15
Source of Power	Water	Steam	Water	Water (Steam Reserve)	Water (Steam Reserve)	Water (Steam Reserve)
Number of Electromotives	14	20	15	61 for the three lines		
Number of Motor Coaches	10	—	—	—	—	—
Weight of Trains minimum	150	190	—	not given		
Weight of Trains maximum	370	380	220			

Three-phase Electromotives on the Italian State Railways.

Type	034	036	038	050	030
Maker	Ganz	Ganz	Ganz	Westinghouse	Westinghouse
Number in Service	2	3	4	40	—
Number Building	—	—	—	45	16
Total Weight, tons	45	62	62	60	66
Weight on Drivers	45	43·5	43·5	60	48
Number of Driving Axles	4	3	3	5	3
Total Number of Axles	4	5	5	5	5
Weight on Drivers, tons	11·3	14·5	14·5	12	16
Diam of Drivers, m.m.	1,396	1,600	1,600	1,070	1,630
Frequency (cycles per second)	15	15	15	15	16⅔
Method of transmitting torque of motor to driving axles	Quill and flexible Coupling	Cranks and Connecting Rods			
Speed, in kilometres per hour	30	32—64	22—45—63	22·5—45	37·5—50—75—100
Method of Speed Regulation	—	Cascade	Cascade	Cascade	Cascade and pole-changing

Railways, which works out at 30 kilogrammes per horsepower.

In conclusion, let us briefly glance at what is being done in the electrification of the Gothard line, that main link of commerce between Germany and Italy. I am indebted for the following notes on the subject to Mr. Huber-Stocker, the scientific adviser to the Swiss Government in the matter of Railway Electrification: The part to be electrified first is that between Erstfeld and Bellinzona, a total length of 110 kilomètres, of which about 29 per cent is in tunnel. This part also contains the longest and heaviest grades, so that the limitations of steam as compared with electric traction are here most prominent and a relief most urgent. On this section the average daily train movement, taking both directions together, was, in 1911, not less than 1,680,000 kilomètre-tons, and the maximum on any day 2,282,000 kilomètre-tons. It is estimated that in 1918 the average train movement will have increased by 35 per cent over 1911, and in 1928 by a further 30 per cent. In the 45 kilomètres on the north side of the tunnel the train climbs 569 mètres, and in the 65 kilomètres on the south it descends to Bellinzona 900 mètres, with a steepest grade of 27 per mille. The section Erstfeld-Airolo is to be opened for electric traction in four years from now, and the southern section one year later. The present arrangements are made with the intention of extending the electric service on the north to Lucerne (60 kilomètres), and on the south to Chiasso (55 kilomètres) at some future date not yet fixed. There will be two large power-stations, one at Amsteg, where at first 32,000 horsepower will be available on the turbine shafts, and 56,000 to 60,000 when the station is completed; and the other at Piotta, where at first 40,000, and finally 50,000 horsepower will be available. The head of water in the northern powerhouse is 267 mètres down to the Reuss, and an accumulation of 1 million cubic mètrics is provided for to compensate for diurnal variations. In the southern powerhouse the head of water is 900 mètres, and there the Ritom Lake offers a natural reservoir, with 19 million cubic mètres, to compensate for annual variation in the water-supply. The power-current will be sent along the line by two independent cables, each capable of carrying the full power at twice 30,000 volts, with earthed neutral. The current will be transformed down to 7,500 volts at first, and 15,000 volts later on, if the experience gained with the lower pressure should warrant the increase to double pressure. This will not involve any additional plant, since the secondary winding of transformers both along the line and on the locomotives can from the first be arranged with this alteration in view. It is also contemplated to establish sub-stations in Biasca, Goeschenen, Lavorgo, and Bellinzona. The trolley wires will be suspended from gantries, each wire independently insulated. The section varies according to the gradient from 100 to 160 square millimètres. The feeders are separate for the up and down line, and are 100 square millimètres in section. At all railway stations there are change-over switches for trolley wire and feeders. In the tunnels the wires are carried by brackets fastened to the crown of the tunnel. The rails will be bonded, and, in addition, there will be a bare return conductor either laid in the ground or placed between the trolley wires. A variation in the supply of voltage of from plus 10 to minus 15 per cent is allowed for. There will be no motor coaches used, only electromotives. It is intended to haul express trains weighing 420 tons with a speed of 50 kilomètres per hour on grades of 26 per mille, for which service the electromotive will have to develop 3,000 horsepower on the rails. Goods trains weighing up to 670 tons will run with a speed of from 27 to 28 kilomètres per hour, and have two electromotives, one in front and one in the rear, each rated at 2,800 horsepower. Passenger trains will be heated by steam, the boiler being carried in a special heating coach. Except for the stipulation that the traction must be single-phase at 15 frequency and a voltage of 7,500, which may eventually be raised to 15,000, no definite type of electromotive has as yet been selected, but there can be no doubt that several of the already existing types of mono-phase electromotive can be adapted to the special requirements of the Gothard line.

PENNSYLVANIA ELECTRIFICATION.

It has recently been announced that the Pennsylvania Railroad will electrify a suburban division between Broad Street Station, Philadelphia, and Chestnut Hill, a total distance of 12 miles. The electrification of the main line between Philadelphia and Paloi, which is the terminus for suburban trains, was announced some time ago. It is estimated that the work on the Chestnut Hill division will be completed in about one year. There are at the present time 66 trains per day on the Chestnut Hill branch and 85 trains per day operating between Paloi and Philadelphia.

THE SOCIETY FOR ELECTRICAL DEVELOPMENT.

It will be of interest to manufacturers, as well as to the other branches of the electrical business, to know that forty-one manufacturers have taken out membership in the society, aggregating over $80,000 annually, as their subscription to this very important trade movement. The particular group of forty-one referred to are members of the Electrical Manufacturers' Club, at whose meeting last month in Hot Springs the society was a live topic of discussion both in the meeting and the lobbies.

The affiliation with the society of the other members of the club is being carefully considered, and their cooperation will undoubtedly raise the subscriptions from this particular group to over $100,000.00 annually.

THE ELECTRICAL BLUE BOOK.

The 1913-14 Electrical Blue Book contains the list of approved fittings promulgated by the National Board of Fire Underwriters, together with a description and illustration of materials and equipment. This is the sixth edition of the book and shows the steady development of this unique manual for the buyer of electrical material.

Additional features published include practical chapters on the following subjects:

"Common Sense Methods of Wiring Calculations for Direct-Current and Alternating-Current Circuits;" "Treatment for Electric Shock;" "Street Lighting Schedule;" "American Institute of Electrical Engineers Code of Ethics;" "Industrial Motor Applications, Giving a Chapter on Care and Handling of Motors and the Motor Requirements of Machinery Utilized in Various Industrial Applications;" "Data on Illumination Calculations;" "Chart for Graphic Analysis of the Two-Rate Power Schedule for Central Stations."

The book is 9 by 12 inches, handsomely bound in stiff cloth covers, and will be supplied by the publisher, the Electrical Review Pub. Co., Chicago, for $2.00.

Freight House Illumination

C. J. Causland

Industrial lighting in its various phases presents both simple and complex problems. A freight house in itself seems a simple thing, but to illuminate it properly, does not admit of such simplicity. Its very construction—the character of work done in it—and the articles which it contains, make the illuminating of a freight house a difficult problem.

When the freight houses now in use were built, the two forms of illuminants were carbon incandescents and arc lamps. Owing to the rapid moving of freight about a house, it was practically impossible to use the arc lamp as the trimmer could find no place to stand a ladder. Consequently the carbon filament incandescent was used. To obtain anywhere near the proper amount of light the sockets were hung about eight feet high and from six to ten feet apart. For instance, in the house shown, there were approximately 200 16 c. p. lamps consuming 12 kilowatts. These lamps, however, were not sufficient and the freight handlers carried oil lanterns about to read the names on the

Night View in Freight House. Note That the Light Is All Placed Where It Will Do the Most Good—On the Freight, Instead of the Side Walls.

shipping and bills of lading. Accidents were frequent. When the rush of freight was heavy, it was a common occurrence to break a bulb. When boxes, etc., were piled upon one another, it was practically impossible to avoid such breakages.

The combination of broken lamps, fire risk from oil lanterns, and poor illumination, brought about an effort to remedy conditions. Various forms of illuminant were tried from clusters of carbon lamps to the gas arc. Clusters proved unsatisfactory because of breakage and poor distribution of light, gas arcs because of frequent trimming and high expense. With the advent of the drawn wire tungsten lamps, a solution to the problem was possible. Various experiments were made with the many sizes of lamps and the most durable and efficient reflector was sought. The conclusions arrived at necessitated the complete rewiring of the building. This was ordered done, taking into consideration the following facts.

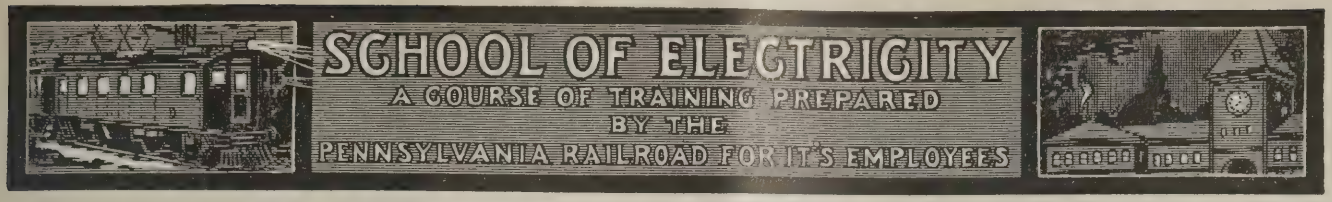
As the ceilings were high the units were to be hung as high as practical. Larger units were to be used to economize on cost of reflectors and lamps. Distribution of light was to be even and sufficient to permit the reading of small writing or printing on the freight tags. The first freight house to be rewired and changed was one situated at Halsted and Kinzie streets, Chicago, and operated by the Pennsylvania R. R. The freight house is approximately 400 x 80 ft., regular in shape, with high hip roof. Conduit was run and so wired that two 250 W. lamps were on

Interior of Freight House at Night. Note the Uniform Illumination and Absence of Dark Shadows.

each circuit. This arrangement was made so as to conform to the city ordinance. 18 in. shallow bowl Benjamin reflector sockets, with a 250 W. lamp were used throughout. The outlets were placed in two rows, 40 ft. apart down the length of the building and spaced 40 ft. apart. The mounting height was 16 ft. to 18 ft. from the floor depending on the construction of the building. Fittings were supplied at all bends so that only short pulls were necessary in drawing the wire through the conduit. Where 12 kilowatts was used to light the building formerly the present consumption is but 5 kilowatts, a reduction of 60 per cent in current. The present illumination averages 1 foot candle on the floor at a current consumption of .15 watt per square foot. The reflectors and lamps are cleaned about once every two weeks.

From the photos it can be seen that every result desired has been gained, the absence of deep shadows being particularly noticeable. On the platforms the object was to get the lamp and reflector out of the way from any objects which might strike them, also to direct the light both into the cars and onto the platform. Here Benjamin white enameled steel angle reflectors with 60 W. lamps were used. By employing an angle reflector all reflection is from white enameled surfaces rather than dark walls, which would be the case were the lamps hung over the center of the platform instead of up where the wall and roof meet. The angle reflectors are of a symmetrical shape and so direct the light that very even illumination is obtained considering the fact that the lamps are hung but 10 ft. high and 30 ft. apart, while the platform itself is but 6 ft. wide. The resultant illumination on the platform is approximately .8 foot candles using about .33 W. per square foot. While the total illumination on cars is approximately 1.25 foot candles.

From a practical standpoint the results brought about efficient and sufficient illumination, quicker handling of freight, less accidents, and more cheerful conditions.



Lesson No. 7.

EVOLUTION.

This is just the reverse of involution. It is the finding of the root (or extracting the root) of any number the power of which is given. Roots are named in a manner similar to the powers; thus, one of the two equal factors of a number is the second or square root; one of the three equals roots is the third or cube root, etc.

The roots and powers of numbers are given in tables in many engineering hand-books, but it is extremely important that one understands how to compute both square and cube root. The diameter of a circle or the side of a square having a given area is obtained only by solving for the square root, and the side of a cube or the diameter of a sphere is obtained by solving for the cube root when the volume is known. Square root is also used a great deal in solving for the sides of triangles and in the applications of many formulas.

The radical sign, $\sqrt{\ }$, placed before a quantity indicates that some root is to be obtained. For example, $\sqrt{81}$, $\sqrt[3]{125}$, $\sqrt[4]{256}$ shows that the square root of 81, the cube root of 125, the fourth root of 256 are to be found. The small figures 3 and 4 are indexes showing what root is to be found if other than the square root.

These same operations may also be expressed by fractional exponents; as $81^{\frac{1}{2}}$, $125^{\frac{1}{3}}$, $256^{\frac{1}{4}}$. Many difficult problems in finding the roots of numbers are solved by logarithms, which will be explained later.

Square Root.

To extract the square root, begin at the decimal point and divide the number into periods of two figures each; thus 329.42567 would be divided 3'29.42'56'70. The operation of finding the square root is as shown in the following:

	3'29.42'56'70'00'00	18.15008+
	1	
20	229	
28	224	
360	542	
361	361	
3620	18156	
3625	18125	
36300	31700000	
363000	29040064	
3630000		
3630008		

As is shown in this computation, the whole number beginning at the decimal point may not have an even number of figures, so that the last period on the left may have only one. In the above number the figure 3 is the last period. The root will consist of as many figures as there are periods or divisions in the original number. The decimal point is located between the two figures corresponding to the two periods or divisions between which the decimal point occurs in the original number. In the above number the decimal point is located between the second and third periods, counting from the left, and is placed between the second and third figures in the root; thus $\sqrt{3'29.42'56'70}=18.15008$. Ciphers may be added to the right of the decimal without changing its value, if it is desired to carry the root to a greater number of decimal places.

Explanation of the Above Computation.

The largest number which, when multiplied by itself, would be equal to or less than 3 is 1. This figure is the first figure of the root, and when multiplied by itself is placed under the first figure (3) from which it is subtracted. Then bring down the figures of the next period to the right, giving the number 229. The first figure (1) of the root is always multiplied by 2 and set down to the left of this new quantity (229). Affix a cipher to it, making it 20. This is now considered as a new trial divisor for the quantity 229. The next step is to find a number which, added to this, can be used as a multiplier of this sum and contained in 229; this is found to be 8. This is added to 20, making 28, and 8 times 28 are 224. Then 8 is the next figure to the root. As 29 is the last period in the original number before the decimal point, the decimal point in the root then follows this figure 8. Subtracting 224 from 229 leaves 5. Then bring down the next period, 42, forming the quantity 542. The right-hand figure of the last trial divisor 28, is next added to this number; thus 28 plus 8 equals 36. Then affix a cipher to 33, making 360, which is the new trial divisor for the quantity 542. The process above mentioned is then repeated to find the next figure of the root, namely, to find a number which, added to this number 360, can be used as a multiplier of this sum and contained in 542. It is found to be 1. Then 361 is the divisor, and 1 times 361 is then subtracted from 542, being 181. The period next in order is brought down, making 18156. The last divisor is then treated as above for a new trial divisor, namely, add the right-hand figure of the number 361 to 361, making 362, then affix a cipher, making 3620. Repeating the above process, the next figure of the root is found to be 5. This is sufficiently far to carry the root, when it comes so close, for any of the ordinary computations. If it is desired to carry it to more decimal places, ciphers may be added to the original number in periods of two each. When the last period was brought down after completing the operation for the figure 5, the quantity of 3170 obtained and the trial divisor was 36300. As this is larger than the number 3170, a cipher is placed in the root after 5, a cipher is added to the trial divisor, making a new trial divisor, 363000, and the next period is brought down, forming the number 317000. The trial divisor is still larger, so that another cipher is added to the root, another to the trial divisor, and the next period is brought down, forming the number 31700000. The trial divisor 3630000 is now contained in this 8 times, which is the next figure of the root. The plus sign after the root indicates that it is not exact and that it may be carried further.

This same process is followed in finding the square root of a whole number. The decimal point should come after the figure corresponding to the last period of the number brought down. If the root is not exact, ciphers may be added after the decimal point of the number and treated the same as above.

In another paper, E-2, it was stated that the resistance of a conductor was dependent upon the area of its cross-section and that it was inversely proportional to the area of this cross-section. Then if the resistance of a given conductor and its area are known, we can compute the area for a similar conductor if its resistance is known, or the resistance if its area is known.

Example: If the resistance of a rod of copper one-half inch square is one ohm for a certain length, what would be the area and diameter of a similar bar having a resistance of three-fourths of an ohm, the length being the same?

Solution: It would obviously be larger in cross-section, as the resistance is to be less. By proportion, assuming that X is the dimension of one side of square rod, $(\frac{1}{2})^2 : X^2 :: \frac{3}{4} : 1$, since the resistance varies inversely as their areas. From a previous explanation of proportion,

$$X^2=(\tfrac{1}{2})^2\times 1\div\tfrac{3}{4}$$
$$=\tfrac{1}{4}\times 1\times 4/3$$
$$=4/12$$
$$=\tfrac{1}{3}=$$ the area of the cross-section

desired in square inches. Then by extracting the square root of this, the dimensions of one side may be found, $\frac{1}{3}=.3333\times$ and $\sqrt{.3333}=.577''$.

Roots of fractions may be found by finding the given root of the numerator and denominator separately; for example,

$$\sqrt{\frac{9}{25}}=\frac{\sqrt{9}}{\sqrt{25}}=\frac{3}{5}.$$

If this is expressed as a decimal, then $\sqrt{.36}=.6$. It is many times more convenient to extract the required root from a decimal than of the fraction, in which case it is obtained as shown in the problem described.

Cube Root: This is the process of finding the third power of a quantity and is a little more complicated, but it is not used as often as the square root. The process of finding this root is best explained by following an example. Let it be required to find the cube root of 329.42567, which would be written $\sqrt[3]{329.42567}$ or $329.42567^{\frac{1}{3}}$. The first operation is to point it off into periods of three figures each starting from the decimal point and pointing off in both directions.

	329.425'670'000 | 6.906+
300×6^2 = 10800	216
$30\times6\times9$ = 1620	113425
9^2 = 81)	
12501)	112509
1701)	916670000
300×69^2 = 1428300	
300×690^2 = 142830000	
$30\times690\times6$ = 124200	
6^2 = 36)	
142954236)	857725416
124236)	58944584

Find the largest figure which when multiplied by itself three times does not exceed the left-hand period. It is seen that $7\times7\times7=343$, so that this is too large, and $6\times6\times6=216$, which is the first figure of the root. This is set down underneath the first period from which it is subtracted. The next period is then brought down, giving the number 113425 for the new dividend. To obtain the trial divisor, the square of the first figure of the root is multiplied by 300, giving 10800. It is seen that this will go into 113425 nine times. The trial divisor is then completed by adding 30 times the first figure and multiplied by the next figure in the root, or $30\times6\times9$, then add 9^2. The sum of these three quantities, 12501, is the complete trial divisor. This is then multiplied by 9, giving the number 112509, which is subtracted from 113425, with a remainder 916. The next period is then brought down, forming the number 916670. The first trial divisor for this quantity is obtained in same manner as preceeding one; thus 300 times the square of the root so far found, or 300×69^2, equals 1428300. This may be more easily found after the first two figures are determined by bringing down the sum of 1620 and 81, which would be 1701 as used in the preceding divisor, then adding the three quantities connected by bracket and adding two ciphers. This obtains the same result as performing the squares and multiplying by 300. This gives a divisor larger than 916670, so that a cipher is placed in the root, making 6.90, three ciphers in the next period are brought down and two ciphers added to the new trial divisor, making 142830000. By inspection it is seen that this is contained in the new dividend 6 times, so that 6 is the next figure in the root; then repeat the same process for finding the complete divisor as previously. In adding the quantities for this divisor disregard the number 1428300, which was a trial divisor for a previous operation. This operation is the square of the figures found in the root 690 multiplied by 300, which gives 142830000, then add 30 times 690 times the new figure 6, which equals 124200, and also the square of this figure 6, which gives as the new divisor 142954236; this is the quantity which is multiplied by 6. If the operation was to be carried out further the next trial divisor would be the sum of the last three quantities in the bracket, to which should be added two ciphers.

Higher Roots: The fourth root is the square root of the square root; the sixth root is the cube root of the square root, or the square root of the cube root. Other roots are easily found by logarithms, which will be explained in another paper.

Problem: Extract fourth root of 256 which would be written $\sqrt[4]{256}$.

Soluti n. First find the square root of 256 which is 16, then find the square root of 16 which is 4.

$$\therefore \sqrt[4]{256}=4.$$

This may be proved by multiplying 4 by itself thus, $4\times4\times4\times4=256$.

Problem: Extract the sixth root of 15625 which would be written $\sqrt[6]{15625}$.

Solution: First find the cube root of 15625 which is 25, then find the square root of 25 which is 5.

$$\therefore \sqrt[6]{15625}=5.$$

This may be proved by multiplying 5 by itself thus, $5\times5\times5\times5\times5\times5=15625$.

Application of Cube Root: A storage battery tank is in the form of a cube and holds 10 gallons of electrolyte when the plates are out; what is the inside depth of the tank?

Solution: From the tables, 1 gallon contains 231 cubic inches; then 10 gallons = 2310 cubic inches and $\sqrt[3]{2310}=13.22+$ inches.

Board and Timber Measure.

The unit of board and timber measure is the board foot, which is one foot square and one inch thick. In order to determine the number of board feet in a board or stick of timber, multiply the length in feet by the width in feet and the thickness in inches. If the width is in inches, divide the product by 12.

The volume in cubic feet of round timber is found by multiplying the length in feet by one-quarter of the mean diameter times the mean circumference or girth. By the "mean diameter" or "circumference" is meant the average, which in most cases would be that of the middle point of the log or pole. When the diameter and girth are given in inches, divide the product by 144. When the length, diameter and girth are all in inches, divide the product by 1728.

Problem: How many board feet shall be ordered to construct a false floor for a battery room 10 x 25 feet and the floor $1\frac{1}{2}$ inches thick? What would this cost at $25.00 per thousand feet?

Solution: Area of the floor is 10 times 25, or 250 sq. ft.; $1\frac{1}{2}\times250=375$ board feet, since the thickness of the floor was $1\frac{1}{2}$ inches; $375\div1000\times\$25.00=\$9.38$.

Problem: How many cubic feet in a telephone pole 45 feet long, having a top diameter of 8 inches and the butt 16 inches?

Solution: Assuming that the pole is a straight taper, the mean or average diameter is $\frac{1}{2}$ (8+16), or 12 inches; then its girth at this point would be $12\times3.1416=37.7$ inches; then $\frac{45\times12\times37.7}{4\times144}=35.45$ cu. ft.

The Circle.

This is a plane figure bounded by a curved line all points of which are equally distant from a point called the center. This curved boundary line is called the circumference. The radius is the straight line drawn from the center to the circumference. The diameter is the straight line drawn through the center and terminating at each end in the circumference It is twice the length of the radius. The circumference is about $3\frac{1}{7}$ times as great as the diameter, or, more accurately, 3.1416. This relation is usually expressed as π, known as "pi". $2\pi r$ = circumference.

Problem: A water tank measures 66 feet in circumference at the base. What will be the length of the longest beam extending across the bottom if it projects one foot on each end?

Solution: $66\div3.1416=21$ feet diameter; $21+2=23$ feet length of beam.

Problem: What is the diameter of a lead-covered cable, to the nearest sixteenth of an inch, if its circumference is 5 inches?

Solution: $5\div3.1416=1.59$ in. $\frac{59}{100}=\frac{X}{16}$ or $X=\frac{59\times16}{100}=9.45$. As this is nearer 9 than 10, this diameter would then be written $1\frac{9}{16}$.

The area of a circle is equal to the circumference times one-half the radius.

Since the circumference is equal to $2\pi r$, the area may easily be expressed in terms of the radius; as, $2\pi r\times\frac{r}{2}$ from previous statement. This is equal to $\pi r^2=A$, the area.

The multiplication sign is many times omitted in writing formulas, but quantities written together as the above expressions are to be multiplied by each other; thus $2\pi r$ is equal to $2\times\pi\times r$.

The area may be also expressed in terms of the diameter. Since d, the diameter, is equal to $2r$ or $r=\frac{d}{2}$, we may substitute in the above equation $A=\pi r^2=\pi\left(\frac{d}{2}\right)^2=\frac{\pi d^2}{4}$ But $\pi=3.1416$, then $\pi\div4=.7854$, and the formula for the area becomes $.7854\ d^2=A$.

The diameter of the circle is also the length of one side of the square which would just enclose or circumscribe the circle. For rough estimating, the area of a circle is eight-tenths (.8) that of the circumscribing square. Then the area of the circumscribing square is approximately $1\frac{1}{4}$ times the area of the circle.

When the area of the circle is given and it is required to find its diameter, the following equation holds true.

$$d=\sqrt{\frac{A}{.7854}}$$

This is derived from the equation $A=.7854\ d^2$

Problem: The area of the circular plot occupied by a turntable is 1257 sq. ft. What is the length of the track, assuming that it is the full length of the diameter?

Solution: $1257\div.7854=1600$. $\sqrt{1600}=40$ feet.

If a copper conductor having an area of 10382 cir. mils has resistance of 5.34 ohms per mile, what will be the diameter in mils of a similar wire having one-fourth the resistance?

Solution: Since the resistance is inversely proportional to the area, the lower resistance wire must be 4 times as great in area of cross-section, or $4 \times 10382 = 41528$. The diameter in mils is the square root of the area in circular mils. Then $\sqrt{41528} = 204$ mils.

From the wire tables these will be seen to agree very closely with the dimensions and resistances of No. 10 B. & S. and No. 4 B. & S. copper.

It might be stated here that the circle contains the greatest area of any plane figure for a given distance around or, circumference.

How does the circumference of a circle having an area of 500 sq. ft. compare with the circumference of a square plot with the same area?

Solution: $\pi r^2 = 500$ sq. ft., then $r^2 = \frac{500}{\pi} = 159.15$ sq. ft., $r = \sqrt{159.15} = 12.62$ ft The circumference of this circle is then 2π 12.62 $= 79.294$ ft.

The circumference of the square having the same area is four times the length of one side $= 4\sqrt{500} = 4 \times 22.36 = 89.44$ ft.

The circumference of the above circle may be found from the equation $C = 3.545\sqrt{A}$, in which A is the area.

Concentric Circles.

Circles are said to be concentric when they have the same centers but different diameters or radii. The space between these concentric circles forms a ring, whose area is the difference between the areas of the greater and the smaller of the circles. Its width (not diameter) is the difference between their radii.

Problem: A turntable 40 ft. in diameter is surrounded by a cinder path 6 ft. wide. What is the area of the path?

Solution: The area of the turntable is 1257 sq. ft.; that of the outer circle is $\pi (20+6)^2 = 2123.7$; thus the difference between these areas is the area of the walk $= 2123.7 - 1257 = 866.7$ sq. ft.

Summary of the Formulas for the Circle.

D = diameter; R = Radius; C = Circumference; A = Area,

$$C = \pi D = 2\pi R = \frac{4A}{D} = 2\sqrt{\pi A} = 3.545\sqrt{A}.$$

$$D = C \div \pi = 0.31831C = 2\sqrt{\frac{A}{\pi}} = 1.12838\sqrt{A}.$$

$$R = C \div 2\pi = 0.159155C = \sqrt{\frac{A}{\pi}} = 0.564189\sqrt{A}.$$

$$A = D^2 \times .7854 = \tfrac{1}{2}CR = 4R^2 \times .7854 = \pi R^2 = \tfrac{1}{4}\pi D^2 = \tfrac{1}{4}CD = .07978\ C^2.$$

From these it will be seen that the circumference may be found direct if the diameter is given, if the radius is given, if the area and diameter are given, or if the area alone is given.

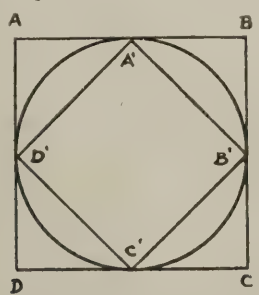
The diameter may be found direct if the circumference is given or if the area is given.

The radius may be found direct if the circumference is given or if the area is given.

The area may be found direct if the diameter is given, if the circumference and radius are given, if the radius is given, if the circumference and diameter are given, or if the circumference is given.

An inscribed square is one whose corners lie in the circumference of the circle; as, A′ B′ C′ D′.

A circumscribed square is one whose sides are tangent to the circle; as, A B C D. It is the square that will enclose the circle, whereas the inscribed square is the square enclosed by the circle.



Relation of Circle to the Square.

Side of an equal square	= Diameter of circle × .88623
Side of an equal square	= Circumference of circle × .28209
Perimeter (circumference) of an equal square	= Circumference of circle × 1.1284
Side of an inscribed square	= Diameter of circle × .7071
Side of an inscribed square	= Circumference of circle × .22508
Side of an inscribed square	= Area of circle × .90031 ÷ diameter
Area of circumscribed square	= Area of circle × 1.2732
Area of inscribed square	= Area of circle × .63662
Diameter of circumscribed circle	= Side of square × 1.4142
Circumference of circumscribed circle	= Side of square × 4.4428
Diameter of equal circle	= Side of square × 1.1284
Circumference of equal circle	= Side of square × 3.5449
Circumference of equal circle	= Perimeter of square × .88623
Circular inches	= Square inches × 1.2732

WEIGHTS AND MEASURES.

Long Measure—Measure of Length.

12	inches	= 1 foot
3	feet	= 1 yard
5½	yards, or 16½ feet,	= 1 rod, pole, or perch
40	poles, or 220 yards,	= 1 furlong
8	furlongs, or 1760 yards, or 5280 feet,	= 1 mile
3	miles	= 1 league

Additional Measures of Length in Occasional Use: 1000 mils = 1 inch; 4 inches = 1 hand; 9 inches = 1 span; 2½ feet = 1 military pace; 2 yards = 1 fathom.

Old Land Measure: 7.92 inches = 1 link; 100 links, or 66 feet, or 4 poles = 1 chain; 10 chains = 1 furlong; 8 furlongs = 1 mile, 10 square chains = 1 acre.

Square Measure—Measure of Surface.

144	square inches, or 183.35 circular inches,	= 1 square foot
9	square feet	= 1 square yard
30¼	square yards, or 272¼ square feet.	= 1 square rod, pole or perch
40	square poles,	= 1 rood
4	roods, or 10 square chains, or 160 square poles, or 4840 square yards, or 43,560 square feet,	= 1 acre
640	acres	= 1 square mile

An acre equals a square whose side is 208.71 feet.

Circular Inch; Circular Mil: A circular inch is the area of a circle 1 inch in diameter = 0.7854 square inch.

1 square inch = 1.2732 circular inches.

A circular mil is the area of a circle 1 mil, or .001 inch in diameter, 1000^2 or 1,000,000 circular mils = 1 circular inch.

1 square inch = 1,273,239 circular mils.

The mil, and circular mil, are used in electrical calculations involving the diameter and area of wires.

Solid or Cubic Measure—Measure of Volume.

1728 cubic inches	= 1 cubic foot
27 cubic feet	= 1 cubic yard
1 cord of wood = a pile 4 × 4 × 8 feet	= 128 cubic feet
1 perch of masonry = 16½ × 1½ × 1 foot	= 24¾ cubic feet

Liquid Measure.

4	gills	= 1 pint
2	pints	= 1 quart
4	quarts	= 1 gallon (U. S. 231 cubic inches, Eng. 277.274 cubic inches)
31½	gallons	= 1 barrel
42	gallons	= 1 tierce
2	barrels, or 63 gallons	= 1 hogshead
84	gallons, or 2 tierces,	= 1 puncheon
2	hogsheads, or 126 gallons,	= 1 pipe or butt
2	pipes, or 3 puncheons,	= 1 tun

The U. S. gallon contains 231 cubic inches; 7.4805 gallons = 1 cubic foot. A cylinder 7 inches diameter and 6 inches high contains 1 gallon, very nearly, or 230.9 cubic inches. The British Imperial gallon contains 277.274 cubic inches = 1.20032 U. S. gallons.

The Miner's Inch: (Western U. S. for measuring flow of a stream of water).

The term Miner's Inch is more or less indefinite, for the reason that California water companies do not all use the same head above the center of the aperture, and the inch varies from 1.36 to 1.73 cubic feet, per minute, each; but the most common measurement is through an aperture 2 inches high and whatever length is required, and through a plank 1¼ inches thick. The lower edge of the aperture should be 2 inches above the bottom of the measuring box, and the plank 5 inches high above the aperture, thus making a 6-inch head above the center of the stream. Each square inch of this opening represents a miner's inch, which is equal to a flow of 1½ cubic feet per minute.

Apothecaries' Fluid Measure.

60 minims	= 1 fluid drachm
8 drachms	= 1 fluid ounce.

In the U. S. a fluid ounce is the 128th part of a U. S. gallon, or 1.805 cubic inches. It contains 456.3 grains of water at 39 degrees F. In Great Britain the fluid ounce is 1.732 cubic inches, and contains 1 ounce avoirdupois, or 437.5 grains of water at 62 degrees F.

Dry Measure, U. S.

2 pints	= 1 quart
8 quarts	= 1 peck
4 pecks	= 1 bushel

The standard U. S. bushel is the Winchester bushel, which is in cylinder form, 18½ inches diameter and 8 inches deep, and contains 2150.42 cubic inches.

A struck bushel contains 2150.42 cubic inches = 1.2445 cubic feet; 1 cubic foot = 0.80356 struck bushel. A heaped bushel is a cylinder 18½ inches diameter and 8 inches deep, with a heaped cone not less than 6 inches high. It is equal to 1¼ struck bushels.

The British imperial bushel is based on the imperial gallon, and contains 8 such gallons, or 2218.192 cubic inches = 1.2837 cubic feet. The English quarter = 8 Imperial bushels.

Capacity of a cylinder in U. S. gallons = square of diameter, in inches × height in inches × .0034. (Accurate within one part in 100,000.)

Capacity of a cylinder in U. S. bushels = square of diameter in inches × height in inches × .0003652.

MEASURES OF WEIGHT.

Avoirdupois or Commercial Weight.

16 drachms, or 437.5 grains,	= 1 ounce, oz.
16 ounces, or 7000 grains,	= 1 pound, lb.
28 pounds	= 1 quarter, qr.
4 quarters	= 1 hundredweight, cwt. = 112 lbs.
20 hundredweight	= 1 ton of 2240 pounds, or long ton
2000 pounds	= 1 net, or short ton
2204.6 pounds	= 1 metric ton
1 stone	= 14 pounds
1 quintal	= 100 pounds

Troy Weight.

24 grains	= 1 pennyweight, dwt.
20 pennyweights	= 1 ounce, oz. = 480 grains
12 ounces	= 1 pound, lb. = 5760 grains.

Troy weight is used for weighing gold and silver. The grain is the same in Avoirdupois, Troy and Apothecaries' weights. A carat, used in weighing diamonds, = 3.168 grains = .205 gramme.

Apothecaries' Weight.

20 grains	= 1 scruple
3 scruples	= 1 drachm = 60 grains
8 drachms	= 1 ounce = 480 grains
12 ounces	= 1 pound, lb. = 5760 grains

Comparison of Tables of Weight.

1 pound Avoirdupois	= 7000 grains
1 pound Troy	= 5760 grains
1 pound Apothecaries'	= 5760 grains

Circular Measure.

60 seconds	= 1 minute
60 minutes	= 1 degree
90 degrees	= 1 quadrant
360 degrees	= 1 circumference

Time.

60 seconds	= 1 minute
60 minutes	= 1 hour
24 hours	= 1 day
7 days	= 1 week

365 days, 5 hours, 48 minutes, 48 seconds = 1 year.

French and British (and American) Equivalent Measures.

FRENCH.		BRITISH AND U. S.
1 metre	=	39.37 inches, or 3.28083 feet, or 1.09361 yards
0.3048 metre	=	1 foot
1 centimetre	=	0.3937 inch
2.54 centimetres	=	1 inch
1 millimetre	=	0.03937 inch, or $\frac{1}{25}$ inch, nearly
25.4 millimetres	=	1 inch
1 kilometre	=	1093.61 yards, or 0.62137 mile

Measure of Surface.

FRENCH.		BRITISH AND U. S.
1 square metre	=	10.764 square feet 1.196 square yards
0.836 square metre	=	1 square yard
0.0929 square metre	=	1 square foot
1 square centimetre	=	0.155 square inch
6.452 square centimetres	=	1 square inch
1 square millimetre	=	0.00155 square inch
645.2 square millimetres	=	1 square inch
1 centiare = 1 square metre	=	10.764 square feet
1 are = 1 square decametre	=	1076.41 square feet
1 hectare = 100 ares	=	107641 square feet = 2.4711 acres
1 square kilometre	=	0.386109 square miles = 247.11 acres
1 square myriametre	=	38.6109 square miles

Of Volume.

FRENCH.		BRITISH AND U. S.
1 cubic metre	=	35.314 cubic feet 1.308 cubic yards
0.7645 cubic metre	=	1 cubic yard
0.02832 cubic metre	=	1 cubic foot
1 cubic decimetre	=	61.023 cubic inches 0.0353 cubic foot
28.32 cubic decimetres	=	1 cubic foot
1 cubic centimetre	=	0.061 cubic inch
16.387 cubic centimetres	=	1 cubic inch
1 cubic centimetre = 1 millilitre	=	0.061 cubic inch
1 centilitre	=	0.610 cubic inch
1 decilitre	=	6.102 cubic inches
1 litre = 1 cubic decimetre	=	61.023 cubic inches = 1.05671 quarts, U. S.
1 hectolitre or decistere	=	3.5314 cubic feet = 2.8375 bushels, U. S.
1 stere, kilolitre, or cubic metre	=	1.308 cubic yards = 28.37 bushels, U. S.

Of Capacity.

FRENCH.		BRITISH AND U. S.
1 litre (= 1 cubic decimetre)	=	61.023 cubic inches 0.03531 cubic foot 0.2642 gallon (American) 2.202 pounds of water at 62° F.
28.317 litres	=	1 cubic foot
4.543 litres	=	1 gallon (British)
3.785 litres	=	1 gallon (American)

Of Weight.

FRENCH.		BRITISH AND U. S.
1 gramme	=	15.432 grains
0.0648 gramme	=	1 grain
28.35 gramme	=	1 ounce avoirdupois
1 kilogramme	=	2.2046 pounds
0.4536 kilogramme	=	1 pound
1 tonne or metric ton	=	0.9482 ton of 2240 lbs.
1000 kilogrammes	=	19.68 cwts. 2204.6 pounds
1.016 metric tons 1016 kilogrammes	=	1 ton of 2240 pounds

Weight of One Cubic Foot of Pure Water

At 32	degrees F	(freezing point)	62.418 lbs.
At 39.1	"	" (maximum density)	62.425 "
At 62	"	" (standard temperature)	62.355 "
At 212	"	" (boiling point, under 1 atmosphere)	59.76 "

American gallon = 231 cubic inches of water at 62 degrees F. = 8.3356 lbs.

British gallon = 277.274 cubic inches of water at 62 degrees F. = 10 lbs.

Second Lesson.

9.—Write out in words the following: (*a*) 13.405, (*b*) 3.0026, (*c*) 25.49013.

10.—Add the following: (*a*) 17.94, 1.002, .138, 26.04; (*b*) 23.17, 102.708, 16.001.

11.—Subtract (*a*) 16.703—10.94; (*b*) 9.086—3.1; (*c*) 27.060—0.9; (*d*) 15.013—14.082.

12.—Reduce the following to decimals having same denominator: (*a*) .04; (*b*) .9; (*c*) .385; (*d*) .0981.

13.—Change to common fraction and reduce to lowest terms (*a*) .125; (*b*) .25; (*c*) .375; (*d*) .20; (*e*) .625.

14.—Change to equivalent decimals (*a*) $^1/_8$; (*b*) ¼; (*c*) ⅓; (*d*) ½; (*e*) $^4/_5$; (*f*) $^8/_{10}$; (*g*) $^3/_{50}$.

15.—Multiply (*a*) 6.842×5.3; (*b*) 52.731×.004; (*c*) 26×.125.

16.—Divide (*a*) 2.68 ÷ 14.2; (*b*) 25.06 ÷ 50.12; (*c*) 1248.3 ÷ 29.4; (*d*) 1098.10 ÷ 1.26.

S. K. F. BEARING PERFORMANCE

The S. K. F. Ball Bearing Company has made public a recent performance of its 412 Railway Type Self-aligning Ball Bearing for car lighting generators. A pair of these bearings are reported to have run 170,000 miles on one of the trunk lines without appreciable wear.

Although these bearings conform in every respect to the standard railroad specifications, their design is such that sixteen one-inch balls are used in each bearing. The retainer is machined from a solid steel forging and the entire bearing is heavy and rugged.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Did you attend the November meeting of the Railroad Electricians' Club? If you were within 400 miles of Chicago and didn't make it, we're telling you right here that you missed something fine, as one of the boys put it, "We got more real good out of that one meeting than from all the meetings of the year at the old Car Lighting Club."

While we don't want to be throwing away too many bouquets at ourselves, we do feel that the new club is going to be of far greater service to the men on the job than the old Car Lighting Club ever was. We're taking up the lessons of the Pennsylvania School of Electricity, as published in the *Railway Electrical Engineer,* and studying this course, lesson by lesson, working out the problems together, etc.

It's a pretty hard thing for a fellow to study a correspondence course all by himself, but where we all get together and talk things over, any points not understood can be brought out more fully.

While there are a couple hundred of the boys subscribing to this paper who will probably attend these meetings, there are about 2,000 men studying this course who cannot attend the meetings, so we have decided to print a brief abstract of the meetings and give solutions of all the problems presented.

We originally announced that all the problems of the Pennsylvania Course would be answered the following month, but when the officials of the Pennsylvania saw this announcement they urgently requested us not to do this, stating that it would defeat one of the chief purposes of the course as far as they were concerned. So we won't attempt to answer the problems just as given by the Pennsylvania, but we will change these problems slightly so we won't get the same answer, but will show very clearly the principle involved.

The meetings will be held the third Monday of every month on the 18th floor of the Transportation Building, Chicago. The General Managers' Association have kindly provided an excellent hall for the club gratis, so there are no dues or membership fees. Next meeting Monday, December 15, 8 p. m.

PROBLEMS.

(Better read over Lesson No. 1, June, 1913, before working these problems.)

Question No. 1. If a 25-watt tungsten lamp is burning on a 60-volt circuit, what is the current flowing through this lamp?

Answer. The total watts in a. d. c. circuit is equal to the product of number of volts times the number of amperes, so the current flowing is equal to the number of watts divided by the voltage. In this problem we have 25 watts being consumed in the lamp on a 60-volt circuit, so when we divide the watts by the volts, (25 divided by 60), we find the current is equal to 25/60 or a little less than half an ampere (.417 ampere).

Question No. 2. If the power costs 10c per kilowatt-hour, what will it cost to burn this 25-watt lamp for 10 hours?

Answer. A 25-watt lamp burning for 10 hours will use 25 x 10, or 250 watt hours. A kilowatt hour is simply a thousand of these watt hours so 250 watt hours is ¼ of a kilowatt hour, therefore, if it costs 10c for a kilowatt hour, it will cost 2½ cents for the 250 watt hours used in burning this lamp for 10 hours.

Question No. 3. If a 25-watt, 110-volt lamp were burned on a 110-volt circuit for the same length of time, what would be the difference in cost of this service over that given in problem 2?

Answer. A 25-watt, 60-volt lamp burning on a 60-volt circuit will use exactly the same amount of power as a 25-watt, 110-volt lamp burning on a 110-volt circuit or as a 25-watt, 30-volt lamp burning on a 30-volt circuit. The total amount of power is the same so long as the lamp is used on a circuit of the proper voltage. Therefore, the total cost for burning this lamp will be the same as in problem 2.

Question No. 4. Suppose the lighting current in a certain building was 220 volts and only 110-volt lamps were available, how should they be connected?

Answer. Two 110-volt lamps should be connected in series across the 220-volt circuit. This will give normal current through the lamps and 110 volts across each lamp.

Question No. 5. What is the resistance in ohms of a 25-watt lamp operating on a 60-volt circuit?

Answer. In problem 2 we find that a 25-watt lamp burning on a 60-volt circuit has .417 amperes flowing through it. Now from "Ohms law," as explained in lesson No. 1, we find that the current flowing in a circuit will be the number of volts divided by the number of ohms resistance, and similarly, if you know the number of amperes and number of volts the resistance is equal to the volts divided by the amperes. The resistance of this lamp is then 60 divided by .417 or 144 ohms.

Second Lesson.

Question No. 6. What is the loss of power in watts in the transmission line if 20 horsepower is being furnished to a motor on a 440-volt circuit 2,000 ft. from the powerhouse, and the line consists of 2 wires, No. 6 B & S hard drawn copper?

Answer. In the first place, we must reduce the 20 horsepower to watts. One horsepower is equal to 746 watts, so 20 horsepower would be equal to 14,920 watts. The number of amperes flowing is then the watts divided by the volts (14,920 divided by 440) or 33.8 amperes.

From the tables of resistance given in lesson No. 1, we find that No. 6 B & S hard drawn copper has a resistance of .40332 ohms per thousand feet. The motor is 2,000 ft. from the powerhouse, therefore, there will be 4,000 ft. of wire in the circuit since 2 wires are used. The total resistance of this wire is then 4 x .403 ohms or 1.613 ohms. From lesson No. 1 you remember that the power lost in the transmission line is equal to the square of the current times the resistance, therefore, the total number of watts lost in the line is equal to 33.8 x 33.8 x 1.6138 or 1,843 watts. This is equal to 2½ horsepower which is lost in the line so there must be 22½ horsepower generated at the station in order to deliver 20 horsepower to the motor. For most service this loss would be considered excessive and No. 6 wires should be replaced by No. 4 B & S gauge of lower resistance and lower line loss.

Question No. 7. What would the loss have been if the voltage had been 2,200?

Answer. To deliver 20 horsepower (14,920 watts), with a 2,200-volt circuit, the current would be the total watts divided by the voltage (14,920 divided by 2,200), or 6.78 amperes. In problem No. 7 we find the total resistance of the circuit to be 1613 ohms. The line loss would then be the product of the square of the current times the resistance (6.78 x 6.78 x 1.613) or 74 watts. This is then only 1/10 of a horsepower line loss as compared with 2½ horsepower at 440 volts. This shows the importance of using high voltages for transmitting power at a distance.

Question No. 8. This line loss is manifested by the drop in voltage between the powerhouse and the motor end of the line, and is called line drop. In other words, this is the voltage which is required to overcome the resistance of the transmission line in forcing the current through it.

(A) What would be the voltage at the powerhouse in problem 6.

(B) What would be the voltage in problem 7?

Answer. In problem 6, we found that it required 33.8 amperes to deliver 20 horsepower at 440 volts. The line resistance is 1.613 ohms, and we find from lesson 1 that the voltage is equal to the current, times the resistance, therefore, it will take (33.8 x 1.613) or 54 volts to force 33.8 amperes through the wire.

If 440 volts must be delivered at the motor end of the line, the voltage at the powerhouse must be the sum of 440 volts and 54 or 494 volts. In problem 7 we find that there is only 6.78 amperes required, therefore, the line drop would be only 6.78 x 1.613 or 11 volts. If 2,200 volts are to be delivered at the motor, the voltage at the powerhouse must be 2,200 volts plus 11 volts or 2,211 volts.

Question No. 9. What size wire with (A) rubber insulation and with (B), weatherproof insulation should be used, disregarding voltage drop for 100 incandescent lamps, each rated at 50 watts on a 110-volt circuit?

Answer. The current through each lamp would be the watts divided by the volts (50 divided by 110) or .445 amperes. One hundred of these lamps would then require 100 times this or 45.5 amperes total current. From table 1, lesson 1, we find that under the column "Rubber Insulation," the allowable current for a No. 6 wire is 46 amperes, this being slightly larger than the total current of 45.5 required for this light circuit, so a No. 6 wire should be used. If a weatherproof insulation be used, we find from the same table in the last column that a No. 8 wire carries 46 amperes, therefore, a No. 8 weatherproof wire could be used.

Question No. 10. What size of wire would be required to feed 10 of the above lamps?

Answer. Since each lamp takes .445 amperes, 10 lamps would take 4.5 amperes, and from table, lesson No. 1, we find under "Rubber Insulation" that an 18 gauge wire will only carry 3 amperes, while a 16 gauge wire will carry 6 amperes. So the 18 gauge wire is not large enough and the 16 gauge wire must be used. If any other type of insulation and rubber is used, however, we find under the last column that an 18 gauge wire will carry 5 amperes, which is more than the 10 lamps will use, so the 18 gauge weatherproof wire may be employed. It should be noted, however, that in most wiring the rules of the fire underwriters prohibit the use of any smaller than No. 14 gauge wire.

Third Lesson.

Question No. 11. What current carrying capacity must the wire have which is used in winding two relays placed in series on a panel board, if the voltage at the board is 110 volts and the resistance of one coil is 100 ohms and the other is 120 ohms?

Answer. Since the 2 coils are placed in series, the resistance of this circuit will be the sum of the two or 220 ohms, and since the voltage is 110 volts, the current will be the voltage divided by the resistance (110 divided by 220) or ½ an ampere. The wire used in winding the relays must then be of sufficient size to carry ½ of an ampere. It should be pointed out, however, that where a wire is used in winding a coil, the heat generated by the current flowing through the resistance of that coil will not be so easily dissipated as when the wire is in conduit or in the open. So if a wire of just the right size for open work be used in winding a coil it will probably get too hot. This point must be given due consideration and larger wire be used, depending upon the peculiar construction of that coil, its radiation, surface, depth, etc.

Question No. 12. How much greater current will a 50-watt lamp on a 30-volt circuit require than a 50-watt lamp on a 110-volt circuit?

Answer. The current in a 50-watt lamp on 110-volt circuit would be the watts divided by the voltage (50 divided by 110) or .455 amperes. The current through a 50-watt, 30-volt, lamp on a 30-volt circuit, would be watts divided by the voltage (50 divided by 30) or 1.66 amperes, or nearly 4 times as great as the 110-volt lamp.

Question No. 13. Assuming that the filament in the two lamps in problem No. 12 are of the same material and are to be operated at the same current density in the filament, how much larger in cross section and how much shorter would the filament in the 30-volt lamp have to be than that in the 110-volt lamp?

Answer. Since the 50-watt, 110-volt lamp takes .455 amperes (see problem No. 12), the resistance of its filament would be the volts divided by current (110 divided by .455) or 242 ohms.

Since the 50-watt, 110-volt lamp takes 1.66 amperes on 30 volts, its resistance must be the volts divided by the current (30 divided by 1.66), or 18 ohms. Therefore, if the filament of the 30-volt lamp, which carries 1.66 amperes, is to operate at the same current density as the filament of the 110-volt lamp, which carries only .445 amperes, it must be proportionately larger (1.66 divided by .445) or 3.7 times larger in area of filament cross section. The resistance of the 30-volt lamp is (18 divided by 242) or only .0744 as great as the 110-volt lamp, and if the filaments were of the same area the 30-volt filament would be only .0744 as long as the 110-volt filament. But it has 3.7 times larger sectional area, so the filament must then be proportionately longer (.0744 x 3.7) or 0.275 as long as the 110-volt filament. In other words, the 30-volt filament will be about 4 times as thick and about ¼ as long as the 110-volt filament.

Question 14. The old carbon lamps require 3.5 watts per candlepower and the modern tungsten lamps require but 1.1 watts per candlepower. How much less current is required in a tungsten lamp than in the old carbon to deliver the same amount of light?

Answer. If it takes 3.5 watts for every candlepower generated in the old carbon and only 1.1 watts for every candlepower of the tungsten, the tungsten lamp will then require only about 1/3 of the current that the old carbon lamp does, or to be exact, 1.1 divided by 3.5 or .312 as much current as the carbon lamp.

Question No. 17. What is the copper line loss in a 2-wire transmission line between 2 points 3,000 ft. apart if No. 6 wire is used and 50 amperes current flowing?

Answer. The resistance of No. 6 hard drawn wire is .403 ohms per thousand ft. and since the points are 3,000 ft. apart, the total length of wire will be twice that or 6,000 ft. The resistance of this will then be 6 x .403, or 2.42 ohms. From lesson No. 1 we found that the line loss, or watts lost in forcing the current through the copper line, is equal to the number of amperes times the number of volts drop in the line, and since the voltage drop is the product of current times the line resistance, the total watts will then be the product of the

square of the current times the resistance, or 50 x 50 x 2.42, or 6,050 watts.

Question No. 18. What would be the amount of this power lost in the line if the current was increased to 100 amperes?

Answer. The line loss is equal to the product of the square of the current times the resistance (100 x 100 x 2.42) 24,200 kilowatts (24.2 kilowatts) this shows that by doubling the current we increase the line loss 4 times. If we increase the current to 3 times that of problem 17 the line loss would be 9 times as great.

Question No. 19. What will it cost at 6 cents per kilowatt hour to pay for this line loss?

Answer. In problem 17 we have 6.05 kilowatts as a continual loss in the line with 50 amperes flowing. This at 6 cents per kilowatt hour would cost $.36 per hour; with 100 amperes flowing, as in problem 18 the power lost in the line would cost $1.45 per hour.

100 amperes would considerably overload a No. 6 wire and should never be allowed, this shows the importance of keeping the copper loss down to a reasonable value by providing a wire of large enough size. Power circuits are usually figured with not more than a 10 per cent line loss, while on lighting circuits this must be very much less on account of the better voltage regulation required.

Question No. 20. If you have a wire that measures approximately ⅛ in. in diameter, what number B. & S. gauge is it?

Answer. The fraction ⅛, when expressed as a decimal is .125. From lesson No. 1 we learned that a mil is 1/1000 of an inch, therefore, ⅛ of an inch would be equal to 125 mils. We find that from table No. 3, of lesson No. 1, that a No. 8 wire has a diameter of 128 mils, therefore, the wire in question is No. 8 wire.

Question No. 21. Suppose you connect two 25-watt, 110-volt lamps in series, what current will flow and what will be the resistance of the circuit?

Answer. As explained in problem 1, the current through a lamp is the total watts divided by the voltage (50 divided by 110) or .455 amperes. The resistance of each lamp is then the voltage divided by the current (110 divided by 4.55) or 242 ohms.

Now, then, if we place these 2 lamps in series the total resistance will be the sum of the 2 individual resistances, or 484 ohms. With this resistance on a 110-volt circuit the current would be the voltage divided by resistance (110 divided by 484) or .227 amperes.

Question No. 22. If these 2 lamps are connected in parallel, what is the conductivity of the circuit?

Ans. By conductivity we mean the ability to conduct electricity; it's just the reciprocal of resistance, therefore, since the resistance of one lamp is 242 ohms, its conductivity is 1/242, the conductivity of the two lamps would be just twice that of one lamp or 2/242, or 1/121. The conductivity of one ohm is 1; of ½ ohm is 2, etc.

Ques. No. 23. What is the conductivity of 242 fifty-watt, 110-volt lamps, and what is the joint resistance of the whole combination?

Ans. As we have found in above problem, the conductivity of each lamp is 1/242, so the conductivity of the whole combination would be 242 times this or 242/242, which is simply one. This is the conductivity of one ohm, therefore, the resistance of the whole combination is one ohm.

Ques. No. 24. What is the resistance of a circuit in which there are two 25-watt lamps, two 50-watt lamps and one 100-watt lamp in parallel on a 110-volt circuit?

Ans. From the problem above, we found that each 50-watt lamp has a conductivity of 1/242, therefore, the conductivity of each 25-watt lamp, which takes only half the current, would be 1/484, and the conductivity of a 100-watt lamp, which takes twice the current, would be 1/121. The joint conductivity of all lamps would then be simply the sum of these fractions, which is equal to 10/484. The joint resistance is then the reciprocal (inverted fraction) of this or 484 divided by 10, or 48.4 ohms.

Ques. No. 25. If we have 2 coils connected in parallel, one of 200 ohms and one of 100 ohms, what is the joint resistance of the two?

Ans. The conductivity of the combination will be the sum of the conductivity of each coil (1/100 plus 1/200), or 3/200, therefore, the resistance will be the reciprocal of this, or 200/3, or 67 ohms.

Ques. No. 26. If another coil of 100 ohms resistance is connected in series with the two coils of the above problem which are connected together in parallel, what would be the resistance of the circuit?

Ans. The resistance of the 2 coils in parallel, as shown above, is 67 ohms, therefore, when another coil of 100 ohms is placed in series with these 2, the total resistance of the circuit will be the sum or 167 ohms.

Question Box

After working out the problems the "Question Box" was passed around and drew a few good questions, as follows:

Ques. No. 1. How can the voltage coil of a lamp regulator be connected so that if the porter forgets to pull the light switch when all individual lamp circuits are turned off, voltage coil of the relay will not discharge the battery during the day?

Ans. The discussion of this question showed that there were several ways this might be accomplished; one was that the wire connecting the voltage coil to negative be connected to the lamp negative side of each of the individual snap switches. It was shown that there would be an objection to this in that the negative side of all lamp circuits would then be connected together and a ground in one would affect all. Another scheme was to connect the lamp voltage relay coil across the generator, this connection being made outside of the automatic switch so that when the generator was dead no current could flow through the coil. The negative connection of the voltage coil is taken from the lamp negative, the lamp resistance being in the negative side of the circuit and the outside of this connection. This coil is then connected between the lamp negative and the generator positive outside of the automatic switch.

It was shown that still another scheme would be to connect the night circuit of the car permanently across the main lamp switch, so that in order to turn out this night circuit it would be necessary to open the switch. This scheme, however, could be employed only in certain classes of cars.

Ques. No. 2. A Newbold generator was found to deliver 30 amperes constant current regardless of speed variation when the resistance contact arm was stuck so that there could be no change in generator field resistance. This was stuck, however, at a high speed point in which a fairly high field resistance was inserted. Why should the generator deliver a constant current to the battery at all speeds with no regulation?

Ans. This seemed to be a kind of a sticker, but the only plausible explanation of this was that the generator was then operating under very light field and the effect of armature reactions would be great. As the machine speeded up the voltage and current would tend to rise, but this increase in current would increase the armature reactions and shift the magnetic field of the generator so that the brushes would no longer commutate at the neutral point and the bucking voltage of the coils intercepted by the shift in the neutral point of the generator field would keep the voltage down to normal value. On higher speeds the armature current

would increase slightly and shift the neutral point still further.

As another illustration of this point, the question was cited which drew first prize in the November Question Box of the *Railway Electrical Engineer*, as to the reason why a generator would require more current to motor it in one direction than in the other. This point is well covered in the answer to last month's question.

It was about 10:30 when we finished discussion so there wasn't much time left for the social features, but it is the plan of the Club to devote a small part of each meeting to getting acquainted with the other fellow.

Don't forget to pass the word around among the boys that these meetings will be held the third Monday of each month, 18th floor of the Transportation Building, Harrison and Dearborn streets, Chicago. Next meeting Monday, December 15th, 8 P. M.

(*Bring your copies of Lessons No. 1 and 2, June and July, 1913, to the meeting.*)

PROBLEMS FOR NEXT MONTH.

These problems will be taken up at the next meeting of the Railroad Electricians' Club and answers will be published in our next issue. Better work them out yourself and write down the answers opposite each problem so that, even if you can't attend the meeting, you can compare your answers with those published in our next issue. The amount of good you get out of this course will depend on the amount of work *you* do.

Fifth Lesson.

Question 27. If a resistance of 1 ohm, and another of 2 ohms are connected in parallel, what is the joint resistance?

Question 28. If 3 resistances are connected in parallel, one of 2 ohms, one of 4 ohms and one of 1 ohm, what is the joint resistance of the combination?

Question 29. How much current will a 15 horse power direct current motor take on a 110-volt circuit?

Question 30. Suppose 10 tungsten lamps are connected in series for yard lighting, and one of these lamps burns out, what is going to happen to the others, and why?

Question 31. Why is hard drawn copper wire used for transmission lines and why is soft annealed wire used for interior wiring?

Question 32. Suppose you have a copper wire of ¼-inch in diameter, what number B. & S. gauge is it, and what is its resistance per thousand feet?

Question 33. Suppose you are buying wire from a foreign concern who measure their wire according to the N. B. S. standard, and you have a No. 8 N. B. S. wire, what is the nearest size on the B. & S. gauge, which is so generally used in America? (See table 4, lesson No. 1.)

Question 34. Suppose you are buying wire from another foreign concern, which use the B. W. G., or Stubs gauge, what should the micrometer be set at to check the diameter of a No. 4 wire? (See table 4, Lesson No. 1.)

Sixth Lesson.

Question 35. What is the relation between a volt, an ampere and an ohm?

Question 36. Suppose you have a resistance of 4 ohms across a 30-volt battery circuit, what will be the current flowing? What will it be if this voltage is increased to 40 volts?

Question 37. Why don't we get the same voltage at the motor end of a power circuit when the motor is running under load, that we get at the generator end of this same circuit? Why does it vary when the load changes even though the voltage at the power station is absolutely constant?

Question 38. Suppose the load on a d.c. motor is doubled, how much more will the power loss in the line be than formerly?

Question 39. Why is it that whenever we transmit power any great distance we always operate the circuit at a high voltage?

Question 40. Suppose you have a yard charging line of ½ ohm total resistance in the outgoing and return circuit, and 40 amperes charging current flowing to the battery, the voltage at the power station is 50 volts. What is the voltage at the terminals of the battery?

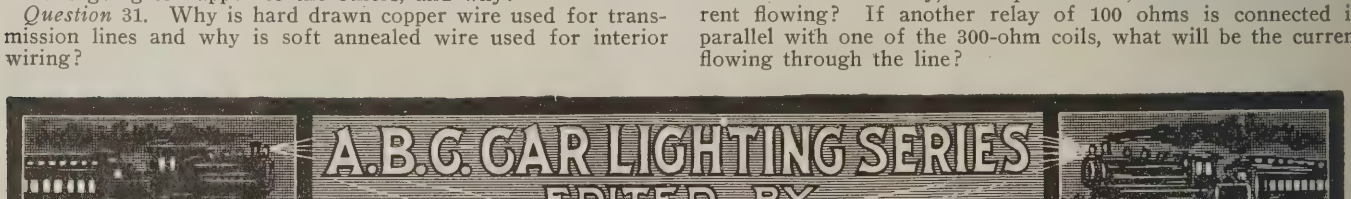
Seventh Lesson.

Question 50. We know that it takes two conductors to complete any electrical circuit. Why is it then that in street railway work only one trolley is used? How does the current get back to the power house?

Question 51. Why do the telephone, gas and water companies complain about this? What can be done to overcome this trouble in a practical way?

Question 52. A telegraph circuit 16 miles between stations uses a No. 8 B. W. G. double galvanized iron wire. What is the total resistance of the circuit?

Question 53. If two 300-ohm relays are connected in circuit with a 150-volt battery, as in problem 51, what will be the current flowing? If another relay of 100 ohms is connected in parallel with one of the 300-ohm coils, what will be the current flowing through the line?



LESSON NO. 23

U. S. L. PANEL NO. S-2.

The S-2 panel manufactured by the U. S. Lighting and Heating Company is radically different from any other car lighting regulator and one of the principal points of difference lies in the fact that it operates as a battery current (or constant generator current) regulator until the battery voltage rises to 42 volts, at which point it changes from a constant current regulator to a constant voltage regulator; and as soon as this voltage is reached the regulator operates so as to reduce the voltage of the generator to approximately the floating battery voltage and the equipment operates at this voltage thereafter, regardless of load or generator speed.

The principles of the operation of this equipment are clearly shown by the diagram, Fig. —, which illustrates the operation of the equipment under various conditions. It will be noted that the generator output is zero until the generator voltage rises to 30 volts, after which time both the generator voltage and current rise to 35 volts and 50 amperes, respectively. This current all goes into the battery excepting what is used in the fields and regulator coils. It will be noted that after a time 25 amperes of lamp current is switched on and this is subsequently reduced to 15 and 10 amperes. It should be noticed that at the time the lamp current is switched on, the generator current increases by 25 amperes and stays constant at 75 amperes until the lamp load is reduced to 15 amperes, when it drops to 65 amperes, and when the lamp load is cut down to 10 amperes

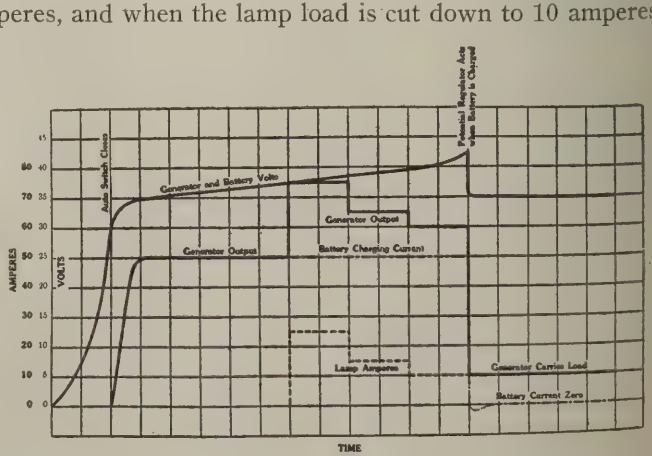


Fig. 129. Showing Operation of U. S. L. Equipment When Adjusted for Constant Battery Current Control.

the generator current reduces to 60 amperes. In other words, the generator output, when the equipment is set for battery current regulation, automatically increases or decreases as the lamp load is switched on or off, but at all times keeps the battery charging current constant at the proper value. Meanwhile it should be noted that the generator and battery voltage has gradually risen from 35 volts to 42 volts. At this time there is a radical change in the way the equipment operates. The battery current

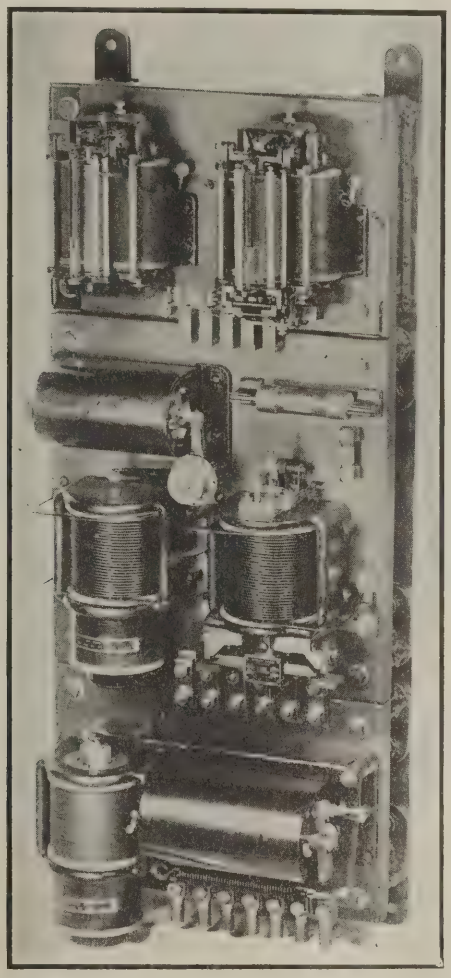


Fig. 130. Type A-1 Panel.

at once drops to zero, in fact, a trifle below zero, causing a slight discharge for a few minutes, and the generator voltage drops to 35 volts, which is approximately the floating voltage of the battery, and the generator is then maintained constant at this valtage, simply carrying the lamp load and field current.

By referring to the wiring diagram, Fig. 131, the connections of the system which accomplish this can be readily followed. Starting from the generator positive, the current flows through the main fuse after which it divides, part going to the potential regulator and part to the series coil of the automatic switch. After passing through the automatic switch the current goes through the double coils of the current regulator and down to positive battery and positive lamps. The generator field current is tapped off the positive main just above the automatic switch and passes through the carbon pile to the contact "J" of the upper panel, thence through the resistance "A", or the short circuiting contact above, to the generator field. The resistance "E" is simply an exciter resistance which allows the weak current of about one-third ampere to flow through the generator field coils when the equipment is dead. This makes it impossible for the generator field to become reversed and although it causes a slight discharge of the battery all the time, the prevention of generator troubles more than warrants its use.

Normally the resistance "A", just below the potential regulator is short circuited and the current regulator solenoid operates the carbon pile so as to reduce the generator field current as the train speed increases in the same way as explained in connection with other carbon pile regulators. There is one feature which should be noted, however, in that the plunger of the current regulator is not connected directly to the lever arm of the carbon pile. When the generator current rises to normal value it picks up the plunger and this simply presses against a small roller on the end of the lever. This pressure is increased as current tends to rise above normal and the plunger forces the lever arm upward against the pull of an adjustable spring and loosens the pressure on the carbon pile in the field circuit. This, as explained before, increases its resistance and as the field current of the generator passes through this carbon pile, increasing its resistance will decrease the current flowing, so as to compensate for the rise in train speed and keep the

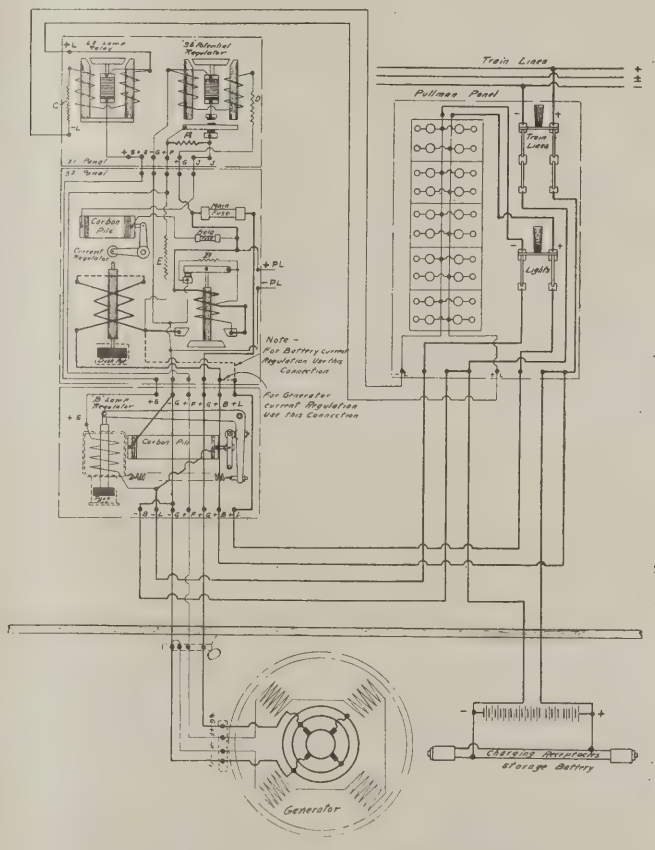


Fig. 131. Wiring Diagram of U. S. L. System With S-2 or A-1 Panels.

generator output at normal value. As the battery charge proceeds its voltage will gradually rise higher and higher, starting at approximately 35 volts and ending at 42 volts as shown in the diagram Fig. 129, but the generator voltage will be just a trifle above this, the difference being simply the voltage drop in the car wiring. It should be noted, however, that there will be a slight variation from this battery voltage curve under different conditions of temperature, current rate, etc.

When the charging battery voltage rises to 42 volts, the magnetism of the potential regulator will then be strong enough to pick up its keeper, shown just above

the resistance "A," Fig. 131. This keeper carries 2 contacts, the one below short circuits the resistance "A", and the one above, when the keeper is drawn up, connects the carbon pile in parallel with the generator field. As soon as this keeper is drawn up it inserts the resistance "A" in the generator field circuit, causing an immediate drop in the generator voltage to 35 volts, as shown in the diagram, Fig. 129. This drop is partly effected by the resistance "A", being in series with the generator field, and partly because of the fact that the carbon pile of the potential regulator is then connected in parallel with the field.

The generator field current then flows from the field fuse through the carbon pile to the contact "J", thence through the resistance "A," after which it divides, part going direct to the generator field, and part going upward through the carbon pile of the potential regulator and thence to generator negative. When the magnetism of the potential regulator becomes strong enough to pick up its keeper, this keeper, which is an iron bar, completes the magnetic circuit at the bottom of the regulator and greatly strengthens the magnetic pull on the tail piece shown at the top of the regulator, which bears on the carbon pile. The bottom keeper comes up solid against the vertical members of the relay, but the tail pieces at the top is free to move slightly. If the voltage of the generator tends to rise above normal, the magnetic pull of these coils on the tail piece will increase, causing an increase in the pressure applied to the little carbon pile inside the regulator. As this carbon pile is connected in parallel with the generator field, increasing the pressure on this pile will decrease its resistance, so more of the current will flow through this carbon pile and less through the generator field. At high speed the amount of current flowing through the carbon pile will be fairly high and that through the generator field correspondingly low, and at low speeds the reverse.

The equipment can readily be changed to operate as a simple constant current regulator instead of the battery current regulator as shown in the diagram, Fig. 129, by simply changing the connection from lamp positive to generator positive, as shown in the wiring diagram, Fig. 131. If it is found desirable to keep the generator voltage at 42 volts instead of immediately reducing it to 35 volts, this can be easily accomplished by simply cutting out the resistance "A"; or an intermediate system wherein the constant potential is set at any desired value, can be obtained by simply decreasing the value of resistance "A", this makes the system a very flexible one and which can be set to produce any type of regulation desired.

The Lamp Regulator.

The lamp regulator is very similar in its operation to that described in our July, 1913, lesson No. 18, and also in lesson No. 13, of February, 1913. It has been somewhat more compactly arranged for inside mounting, however, as will be seen from Fig. 130, when it is mounted at the bottom of the panel. This panel as shown, is the A-1 type panel which differs from the S-2 type only in the detail of construction, the electrical principles of operation being exactly the same.

The windings of the S-2 lamp relay, as shown in the wiring diagram, Fig. 131, are connected directly across the lamp terminals. If the lamp voltage tends to rise above normal it increases the pull on the iron tail piece, which presses on the carbon pile of the relay. This carbon pile is connected in series with the winding of the main lamp regulator and if the pressure on this pile is increased slightly, due to a very slight rise in lamp voltage, it will decrease the resistance of the pile and allow a much larger current to flow through the winding of the main lamp regulator. This will then pull up its plunger strongly, which acting through a system of levers will decrease the pressure on the large carbon pile which is placed in circuit with the lamps. Decreasing the pressure on this pile will increase the resistance and so increase the resistance in the lamp circuit, cutting down the lamp voltage to normal value.

Automatic Switch.

Although this automatic switch is similar in principle to other types previously described, a word of explanation will not be out of place. The automatic switch is of exactly the same size and looks very much like the current regulating solenoid. These two coils are shown near the center of the panel, Fig. 130, the one on the right is the auto-switch. It will be noted that the tail piece is made up of flexible copper strips beveled on the ends so as to wedge in solid between the two beveled copper contacts. Carbon contacts are mounted below this tail piece, which first make contact on closing and are the last to break contact on opening the switch, all arcing then takes place on the carbon tips instead of the copper strips. It will be noted from the wiring diagram, Fig. 131, that when the switch closes it raises a contact at the top of the switch which inserts the resistance "B" in series with the shunt lifting coil of the automatic switch. When the switch is open, this resistance is automatically short circuited by the contact as shown. This reduces the current through the shunt lifting coil as soon as the switch closes and consequently cuts down the heating and power lost in this coil. As soon as the switch closes the generator current flowing through the series coil of the switch pulls it up solid so that the full magnetism of the shunt coils is no longer required.

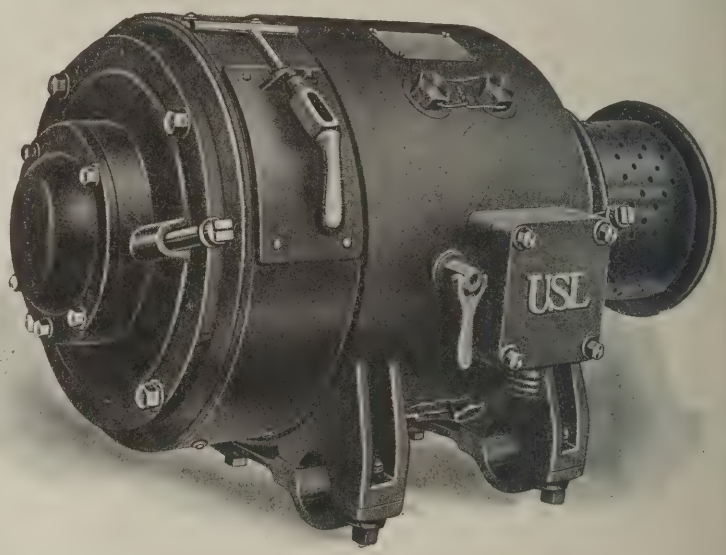


Fig. 132. U. S. L. Generator.

This also provides that the reverse current through the series winding, which neutralizes the shunt magnetism in opening the switch, will not be of as large a value as where this device is not employed, so the switch opens with less arcing.

Generator.

The generator, as shown in Fig. 132, is mounted on a parallel link type suspension. There are various sizes of the types M, O, or C generators in capacities from 1.6 to 3.2 Kw. for either 30 or 60-volt operation,

which can be used with this regulator. The new type "C" generator is 2 in. longer than the type "O" machine, but of the same diameter and general construction.

Pole Changer.

Pole changer of this generator was described in our lesson No. 18, July, 1913. The brush rig is free to revolve through an angle of 90°, so when the generator is driven in the reverse direction the friction of the brushes on the commutator causes the brush rig to shift through an angle of 90°.

The generator has four poles so the brushes are placed 90° apart; shifting the brush rig 90° brings the positive brush where the negative brush was formerly, but the polarity of the armature has been reversed because of the reverse in direction of rotation, so the positive brush will always make contact at the positive point of the commutator and the negative brush always at the negative point regardless of the direction of rotation.

Prize Question Box

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

Better send in your questions now, while you think of it.

First Prize

Lightning Arresters and Choke Coils.

Ques. We have a 5,000 volt overhead transmission line 5 miles long, and at the power house have fuses on both the primary and secondary side of the transformer. We are going to take out the fuses on the secondary side and also the lightning arresters and choke coils and install an oil circuit breaker instead. Don't you think it is a bad idea to take the lightning arresters and choke coils out? If this is done I do not see where we will have any protection in case of storm.

Ans. It is certainly a mistake to remove the lightning arresters and choke coils from the secondary or high voltage side of the transformer at the power station. Lightning arresters should be placed on a pole near the power house and the choke coils somewhere between. The oil circuit breaker will protect the generator equipment within the power house from overload on the discharge of power current which will follow the lightning flash to ground, but will not in any way protect the equipment within the powerhouse from the extremely high voltage and usually low current of the lightning discharge itself. This can only be taken care of properly by a suitable installation of choke coils and lightning arresters. As a matter of fact, there should be pole arresters on each wire in the middle and farther end of your five mile transmission line, as well as at the power house.

Second Prize

Battery Voltage.

Ques. Why is it that no matter how large or how small a cell may be, it will only show a voltage of approximately 2 volts?
H. B. Hope.

Ans. A single positive plate and a single negative plate, if fully charged, will deliver current at slightly over 2 volts. This is a fundamental fact that we simply know, just as we know that a book will drop to the floor if you let go of it. So I don't think that part of the question needs explanation as to why it's 2 volts instead of 1 volt per cell.

We all know that if 2 storage cells are connected together in multiple, that is, the two positives and the two negatives connected together, the voltage of the combination will be simply that of one cell. As a matter of fact, no matter how many cells you connect in parallel the voltage of the entire combination would be only 2 volts. This will explain the reason why a large battery has only the same voltage of a small one, for it simply has a larger number of plates, all connected in parallel, and the voltage of the whole set of plates is just the same as the voltage between any single positive and any single negative plate.

Third Prize

Cadmium Test.

Ques. What is a cadmuim test for, and how do you make it?

Ans. When batteries are given their annual cleaning and overhauling it is very often found that the positives may be badly worn out while the negatives are still in good condition. The voltage delivered at the cell terminals is made up of two separate potentials, the potential between the negative plate and the electrolyte and that between the positive plate and the electrolyte. By means of the cadmium test we can separate these two potentials and find if one or the other of them is below normal. Which ever set of plates shows up low in potential can be either given special treatment to bring them up to full capacity, or can be relaced with new plates. This matter is more fully explained in our lesson No. 5, published in June, 1912.

U. S. Tye C-5 Panel.

Please explain the action of the taper charge relay on the Bliss type C-5 panel. James Hart.

As the charge of the storage battery proceeds its voltage will gradually rise from about 34 volts at the beginning to approximately 42 volts near the finish of charge and the generator voltage will rise corresponding, always keeping a little ahead of the battery voltage in order to force the current into the battery. When the battery gets up to 42 volts the voltage coil shown at the upper left hand corner of the panel, Fig. 103, Lesson 18, will then be sufficiently energized to attract the iron vibrating reed. Just as soon as it does this, however, it opens contact at the right hand end of this reed, which causes current to flow through its own differential coil, and this immediately reduces the magnetism of the voltage coil which lets the reed rise and again makes the contact, short circuiting the differential coil; as soon as the differential coil is short circuited, the magnetism of the voltage coil is strong enough to pull the reed down again, thereby opening the contact, energizing the differential coil and allowing the reed to rise again. This action takes place very rapidly, in fact, so fast that the reed actually vibrates. It will be noticed that when this reed is up it short circuits the shunt winding of the main regulating solenoid, but when the reed begins to vibrate it allows current to flow through this shunt coil for a small fraction of a second every time the reed opens the short-circuiting contact.

It should be understood that the magnetism of this fluttering current through the shunt coil creates a certain number of "ampere turns" of magnetizing force, which simply replaces an equal number of "ampere turns" in the main series winding. As the voltage of the battery and generator tends to rise above normal, the reed will be held open more of the time and consequently the current allowed to flow through the solenoid a greater portion of the time. This will increase the effective "ampere turns" of the shunt coil and accordingly reduce the "ampere turns" and current through the main series coils. This causes the generator charging current to taper off after a voltage of 42 volts has been reached since the generator voltage cannot rise above this point.

Practical Stunts

We pay a dollar apiece for practical stunts. Send in your ideas.

Testing Fuses on the Road.

In through inspection work where the time is very limited, an inspector often finds it necessary to test out new code fuses when he finds an equipment not working, as we find that all enclosed fuses do not indicate when they are blown. The following method is a very simple and handy test:

By removing the main fuse, and placing same across the switch contacts on a "U. S. L." automatic switch, or the Moskowitz switch, there will be a small spark if the fuse is not blown. In the case of the USL&H Co.'s automatic switch, such as used on C-7 panel, the switch will close if adjusted near the proper voltage.

A. Voigt.

Slotting Commutators.

I have found that particularly with the commutator of the "Stone" axle generator it is possible to double the life of the commutator by proper treatment. A commutator which is carefully turned and properly slotted will rarely cause trouble. Wear will take place evenly over the entire surface of the commutator. But when the commutator is turned only and not slotted, high mica soon develops and gives trouble.

Locating a Ground on a Battery.

If a ground occurs on one or more cells of the battery, this can be located by connecting one side of the volt-meter to ground, and with a lead from the other side touch the terminals of each cell.

You will get a reading from every cell except the one that is grounded.—E. L. Work.

Nobody Has Troubles Like the Editor.

To the Editor:

The November number at hand and I find it exceedingly interesting, but I notice that in printing the second one of my practical stunts, the one referring to undercut mica, you printed the prologue and the epilogue but omitted the stunt, thus rendering it something like the picnic sandwich—two slices of bread but no meat.

The meat in this case was to the effect that the best way to undercut mica in a commutator is to use a three-cornered file and cut only a little below the surface; but as the copper would soon wear down to the mica again this method necessitates too frequent handling for a car lighting armature. It, therefore, has been the practice to use a knife-blade, file or a back saw blade and cut much deeper. This gives a deep slot for the collection of carbon dust and oil, which soon becomes packed in to a sufficient extent to carry enough current to melt the solder from around the leads.

I have found that an entirely satisfactory method of preventing the collection of dirt in the slots is to fill them with a paste made of shellac and plaster paris. This mixture does not set as rapidly as plaster paris and water, but it sets much harder and is a better insulator. It also wears down with the copper and thus overcomes the troubles from high mica.

C. B. Jennings.

IMPROVED LONG BURNING FLAME ARC.

A new long burning flame arc lamp has recently been brought out by the Koerting & Mathieson Company, of New York. This lamp contains many features in design and operation which seem to be a decided improvement over past practice. This lamp which is called the "Excello Duplex" is provided with a double gravity feed mechanism. After one pair of electrodes is burned down to a certain point a mechanical trip is automatically raised, bringing the second pair of electrodes into circuit. One pair of electrodes is always locked to make it impossible for both sets to be burning at the same time. There is a double electrode chamber provided at the arc points which prevents the reserve electrodes from becoming covered with vaporized matter before they are used. The illustration herewith shows the path of the ventilating air through the lamp. Air is admitted through the small baffle plates of the ash tray at the bottom and follows the path designated by the arrows. This creates a slight draft upward through the center chamber past the burning electrodes which carries out the electrode fumes, passing upward near the outer wall of the lamp case; here the gases are

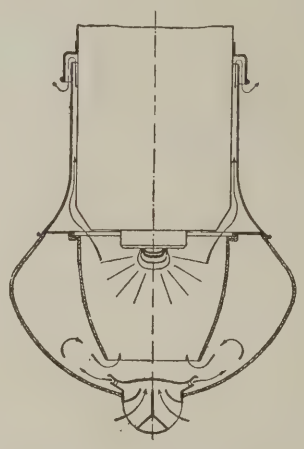
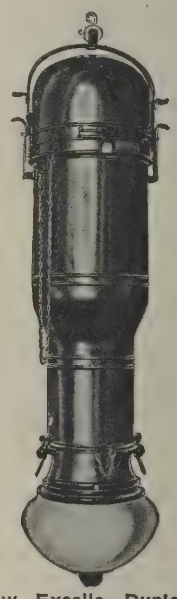


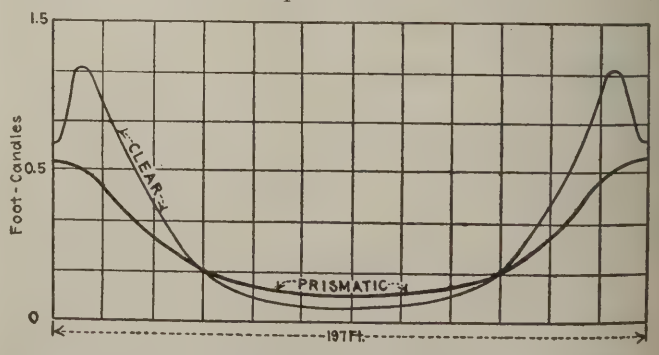
Diagram Illustrating Flow of Air Currents Through the Lamp.



New Excello—Duplex Lamp.

cooled and the fumes largely deposited on the walls of the case. In cleaning the lamp, the trimmer lowers the globes and wipes this surface with a cloth.

The lamp is designed for operation on either alternating or direct current circuits and consumes approximately 10 amperes at 38 volts, a total wattage of 382. With no auxiliary inductance in the circuit, the power factor of the lamp is said to be 0.83.



Illumination Curves Showing the Effect of Using a Prismatic Globe in the Lamp.

General News and Personal Mention

TALIAFERRO MILTON.

No, this isn't the name of a new breakfast food, nor a mallet compound coming up a heavy grade—it's the name of a fellow, and a mighty good fellow, that you will be glad to meet and get acquainted with for he has just taken charge of the western car lighting business of the Electric Storage Battery Company, with headquarters at their Chicago office.

Mr. Milton, although new in the car lighting game, has

Mr. Taliaferro Milton.

had a long experience in storage battery work and other lines of electrical engineering. He graduated from the Virginia Military Institute in 1897, and after studying medicine for a year, became Assistant Professor of Physics at the Institute from 1899 to 1903. He then entered the engineering department of the Westinghouse Electric & Mfg. Company at East Pittsburgh, and in 1905 was employed in the electrical department of the New York Central Lines, where he worked on the design of electrical equipment for the electrified zinc of that system. Since 1906 he has been with the Electric Storage Battery Company in various capacities of Engineer of the Cleveland and the San Francisco office, Manager of St. Louis office, and now holds the title of District Engineer of the Chicago office.

He is a member of the Western Society of Engineers, the Society of Automobile Engineers, and the Association of Railway Electrical Engineers.

ELECTRICAL DEPARTMENT OF FRISCO EXTENDED.

It has been announced that the electrical department of the Frisco System will take over the care and operation of all gas electric cars as well as all matters pertaining to installation of electrical power and lighting equipment in the shops and terminals.

This road has 7 gas electric cars in operation which are showing some remarkable operating results, an average of 16c per mile (which includes all costs of operation, maintenance, repairs, etc.), being obtained.

Mr. L. C. Hensel is chief electrician of the Frisco Lines and this equipment now comes directly under his supervision.

U. S. L. NOTES.

The U. S. Light & Heating Co. announces the removal of its New England sales office, formerly located at 84 State street, to 25 Irvington street, Boston, Mass. This change brings the New England U-S-L Service Station and Sales Office under one roof, an arrangement which it was deemed advisable to make because of increase in business and because of the greater opportunity afforded for close co-operation between the two departments.

EDISON'S NEW BATTERY FACTORY ALMOST COMPLETED.

The large plant of the Edison Storage Battery Company at Orange, N. J., is practically completed and only awaits the installation of machinery to start making the Edison alkaline, nickel-iron storage battery on the enlarged basis made necessary by the rapid development of storage battery applications in train lighting, electric trucks and pleasure cars, street and railway cars, etc. By the latter part of December it is expected that all new machinery will be received, the present machinery rearranged to more efficient positions in the enlarged plant and an addition of over 2,000 new employees required.

DELTABESTON WIRE FOR HEADLIGHT ARMATURES.

Practical operation of headlight generators has developed the fact that ordinary insulation deteriorates rapidly. This is due to the fact that a high temperature is developed, due both to the external heating from the locomotive and the internal heat generated by the current flowing through the field and armature coils. "Deltabeston" wire has proven itself a life saver to the headlight maintainer, for when the coils are wound with this wire the troubles from overheating (short circuits, grounds, etc.) disappear.

This special wire, known as "Deltabeston" consists of ordinary soft copper wire of either round, square or flat sections in any size, over which is carefully laid a thin coat of asbestos fibre thoroughly impregnated with a special insulating compound. This is then carefully finished off so as to present a smooth and uniform surface. The wall thickness of this insulation is no thicker than that of ordinary double cotton magnet wire and the fibres of the asbestos lay, for the most part, on a spiral so that when the wire is bent, even at a sharp angle, the insulation does not open up; the impregnating compound thoroughly soaks into the fibre of the asbestos, rendering it flexible and tough.

This insulation will stand a red heat, the limit being the oxidation point of the copper. Even when the coils have been overloaded until they warm up to a red heat, the insulation of the Deltabeston wire, on cooling down, is found to be about as effective as ever. This insulation is not affected by either oil or water when coils are properly prepared and does not become brittle with age.

"Deltatape" is also used in headlight service with great satisfaction. It is made of pure asbestos fibre impregnated with an insulating compound of heat resisting properties. It will stand a temperature of 400 to 500 degrees Fahr. without injury and even though

Collected for You

is everything you need in electrical supplies and orders if you buy from the Central Electric Company. discount sheet is the key to this immense stock.

Safety, Comfort, Economy

These three essentials make for passenger service. The Alexalite embodies safety in illumination because all parts are metal.

There is solid comfort from the Alexalite system of illumination because all light points are concealed from the range of vision and the illumination approximates daylight.

The Alexalite is economical because of its low cost of maintenance.

The Maxolite Gives 55% More Light, Saves 20% in Power

The Maxolite is an ideal direct lighting fixture for railroad yard, factory, machine shop, etc. It is a ***one piece*** porcelain enamel steel reflector with high illuminating efficiency. There is nothing to wear out.

In one factory twelve Maxolites equipped with Mazda lamps, replacing arc lamps, showed a saving of nearly $450 in less than five months, giving 55 per cent more light.

OKONITE
TRADE MARK
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On all orders for insulated wires where service is desired, specify Okonite. Okonite insulation with its toughness, elasticity, and high electrical resistance is always placed con-

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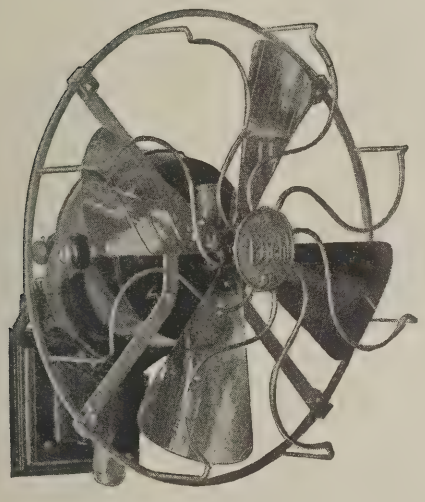
Under One Roof

apparatus. It is not necessary for you to split your Our Silver Anniversary Catalogue, Number 28, and Write for this catalogue on your letterhead.



Diehl Car Fans

give a finishing touch to passenger comfort. Just the turn of a switch in a closet by the porter starts the fan. It is silent and unobstructive. The fan body is readily removed from the base without disturbing the wiring. The general design of both base and fan body is pleasing. Diehl car fans make for greater comfort.

D. & W. Non-Arcing Refillable Fuses

save you 65 per cent in fuse cost. This saving is due to the fact that they may be refilled at low cost. Some of their advantages are: full rating on label; safe indicator; no metal exposed; extra heavy caps and tubing; ampere capacity stamped in fiber and perfect alinement of soldered blades.

centrically around the conductor. The result is a product absolutely dependable. The wiring installed in railway cars should be the best. Okonite is made in one grade only—the best.

OKONITE
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ir Company

of Service CHICAGO

the temperature goes above that point, the asbestos fibre still has good insulating properties.

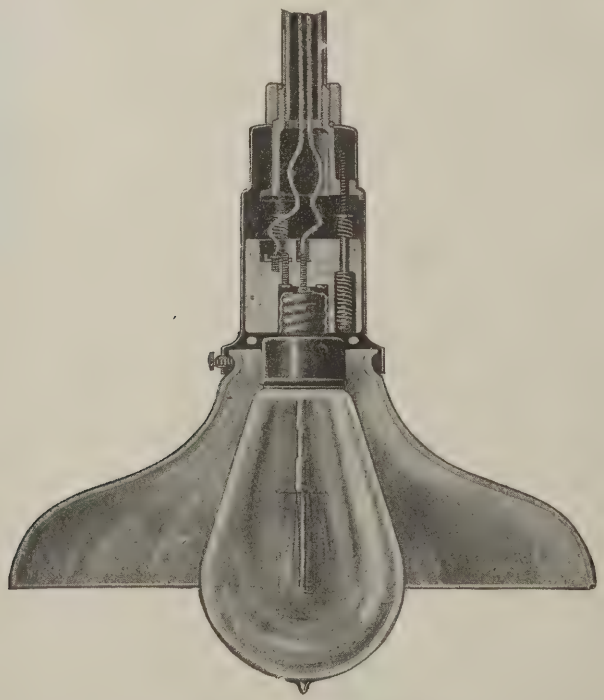
This tape is flexible and does not harden with age. It has a tensile strength of approximately 100 to 200 pounds per inch of width. It is made in any width up to 8 inches and in thickness from 10 to 25 mils. It will stand a voltage test of 2,500 to 5,000 volts, depending upon the thickness. It is used for slot insulation, insulation of magnets, for ribbon wound fields, etc., taking the place of fish paper, which under the temperature sometimes experienced in headlight operation, would carbonize.

In car lighting service, although the temperatures experienced are not so severe as in the headlight service the heat resisting properties of this wire and tape highly commend them for this service.

PROPER CONTROL OF LIGHT DISTRIBUTION.

It is very often found in practice that it becomes advisable to increase or decrease the intensity of illumination, or to change the distribution of the light so as to light a larger area, or concentrate the light so as to illuminate a small area intensely. An ingenius device, which is incorporated in the new "Idealite" fixture manufactured by the George Cutter Company, South Bend, Ind., makes it not only possible to produce the above results, but has additional features of protecting the lamp from vibration.

The lamp socket, which is made of molded insulation, is suspended between six springs, three above, and three below, as shown in the accompanying illustration. A long thread passes through each double set



Cutter "Idealite" Fixture. Lamp Is Supported on Springs to Protect It From Jar and Three Long Screws Through Socket Make It Possible to Adjust Lamp So as To Get Any Type of Light Distribution Desired.

of springs and supports the lamp and socket from a rigid collar above. By adjusting these screws the lamp may be raised or lowered to any desired position, so that if the lamp is replaced by a larger or smaller one, the center of the lamp filament can be brought to the proper position so as to give the desired distribution. If a more extensive type of illumination is required, that is, illuminating a larger area, this can be obtained by lowering the lamp. On the other hand, if it is desired to illuminate a small area intensely, the lamp can be raised in the reflector by means of these 3 screws and gives the effect of a more concentrating type of reflection.

Since the lamp is supported between springs, this fixture will greatly increase the life of the lamps when used in machine shops, freight houses, train sheds, and other locations where there is sometimes severe vibration. The adjustable feature of the fixture, however, should commend it for general use in stations and offices. It will accommodate any of the standard reflector necks. The body shell can easily be raised at any time for inspection. Extra flexible wire is used so as to permit the socket to move freely, thus absorbing all shock and vibration.

NEW REFLECTORS AND HOW TO USE THEM.

The Crouse-Hinds Company, of Syracuse, N. Y., has issued a bulletin devoted to Reflectors for use in roundhouses, steel mills, etc. The bulletin also contains instructions as to how and where the Reflectors should be mounted, to give the maximum amount of light where needed.

These Reflectors are in two general styles. One

Special Reflectors for Dirty Places, Such as Round Houses or Foundries.

type, RM, is not unlike, in appearance, an electric car headlight, and the other, type RS, is bell-shaped. Both have case-iron cases and are gasketed, to make them gas, dust and weather-proof.

BALL BEARINGS.

The Hess-Bright Manufacturing Company have just issued an interesting little booklet on the subject of ball bearings for car lighting generators. This is a subject which is new to most of us and this booklet should be of special interest to car lighting men. A copy will gladly be forwarded to any of our readers upon request to the Hess-Bright Mfg. Co., Philadelphia, Pa.

NEW G. E. BULLETINS.

The General Electric Company has recently issued Bulletin A4131, describing its storage battery locomotives. The bulletin outlines the general conditions under which the use of such locomotives are desirable or advantageous, and illustrates and describes various devices and sizes which have been built and placed in service. The bulletin is accompanied by a data sheet for the use of those who wish further information on this subject.

Bulletin A4167 is devoted to the subject of Electricity in Iron Foundries. The bulletin is profusely illustrated with some typical applications of G-E motors in iron foundries, and contains a chapter on Foundry Lighting. For those looking for information on this subject, the bulletin should be of great interest.

Bulletins Nos. 4171-2-3 describe the most recent development in ventilated railway motors.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Purchase of Power for Electrification

The purchase of power for electrification of the Pennsylvania suburban lines at Philadelphia, as announced in another part of this issue, indicates a situation which will undoubtedly become more evident as electrification projects are extended.

It is good economy for the railroad, in most cases, to purchase electrical energy for the operation of its electrified zone, rather than maintain its own generating plant, provided there is available an efficient central station of a capacity enough larger than the maximum railroad load so that the fluctuation in the railroad load, which must necessarily be at a low load factor, will not greatly affect the load factor and economy of the central station. The average central station in metropolitan centers can operate larger generating units and run them at a more economical load than would be possible by the railroad.

Out of the 650,000 k.w. consumed in New York, but 55,000 k.w. is required to operate the electrified zones of the Pennsylvania, the New York Central and the New Haven systems. It is therefore seen that although the railway load would require the installation of one or more large generating stations, it is but a small item when the generating capacity available from the central station is considered.

Problem of Lamp Testing

The paper presented before the October convention of the Association of Railway Electrical Engineers on this subject by Mr. P. S. Millar and Mr. L. J. Lewinson gives us some information of a semi-confidential nature regarding the much-mooted question of lamp testing. Railroads are among the largest purchasers of incandescent lamps in the country and, with the possible exception of a very few roads, can be justly criticised as being either neglectful, in that lamps are purchased without test, or as being unnecessarily exacting in the matter of rejection of lamps based on a sample test of a very small percentage of the total number.

As pointed out in this paper, the rejection of packages of lamps in which badly rated lamps are found will actually lower the average quality of the lamps finally accepted. By rejecting simply the lamps found to be inferior, and accepting the balance, the average quality of the shipment will be improved, the expense of test and manufacturer's cost of handling minimized and the manufacturer will have a greater respect for the purchaser's fair treatment and be more inclined to co-operate in improving quality than where the entire package is irrationally rejected in each case.

With the modern tungsten lamp the average quality is shown to run very much higher than in previous years, a fact consoling to the railroads who do not test their lamps. But, in any event, the haphazard tests by inexperienced men, which are often made by railroads, can neither accomplish anything material in improving the average quality of the lamps purchased, nor will it induce the manufacturer to improve the general quality of his lamps. A consistent series of life tests, however, conducted systematically by an organization so excellently well qualified and of so wide an experience in this particular line as the Electrical Testing Laboratories, when working in co-operation with the various lamp manufacturers, as they now do for many of the large central stations, will both improve the average quality of the lamps furnished railroads, as well as improve the general quality of lamps manufactured. Something consistent and tangible will thus be accomplished at a minimum cost to the railroads.

Car Lighting Maintenance in the Winter Time.

The months of January and February are probably the two most severe months of the year for the operation of car lighting equipment. Part of this is due to belt trouble on account of ice and snow and part due to the generator oil wells freezing up and the lubricating system failing to work, and part due to inefficiency of the men in cold weather. Few people aside from those actually engaged in caring for these equipments realize the extremely severe conditions of operation which they encounter; that of being continually subjected to the pounding and lash of a truck traveling at high speed, where flying ballast and sand, water, snow and ice, all militate against the successful operation of the equipment. Often times in severe weather the generator, truck, belt and all become encased in a housing of snow and ice; but even under ordinary winter conditions ice and snow frequently pack on the axle and armature pulleys and make belt operation difficult.

Within the past year, however, the advent of ball bearings seems to have eliminated at least one of the main causes of generator trouble, that of frozen lubrication. As the balls and inner race-way travel directly in the lubricating grease there can never be any doubt as to lubricant getting to the point where lubrication is needed, regardless of what the temperature is, so long

as the supply of grease holds out. If the application of ball bearings to car lighting generators had eliminated only this one source of trouble, failure of lubrication, their application would be more than justified. From the practical experience with the operation of ball bearings in this service, however, it has been found possible to extend the period of inspection and lubrication to a six months' schedule. The reduction in maintenance costs and the reduction in lighting failures effected thereby are marked.

Problem of Incandescent Lamp Testing*

By Preston S. Millar and Leonard J. Lewinson

As management becomes more scientific and less haphazard, the importance of ascertaining the facts bearing upon all phases of an industry is becoming more generally recognized. This statement applies to purchasing operations where quality of materials, apparatus and supplies, as well as the price paid, is studied more and more carefully as time goes on. In the development of this practice the railroads of the country are prominent, and it appears to be the general testimony that well designed, carefully executed and intelligently applied tests contribute to economy and reliability.

In the course of growth of testing, the practice has finally been applied to incandescent lamps by some of the railroads, and it is understood that still other railroads have such tests in contemplation. It may, therefore, be timely to discuss briefly the problem of incandescent lamp testing and to consider the peculiarities which differentiate it from tests of other supplies and materials. These peculiarities are notable, being such in fact as to demand in some instances different applications of the principles or the practice of purchasing subject to test. Most of these peculiarities of the product have their source in the characteristics of the lamps themselves, and are apparent when the characteristics of the lamps are understood.

In order that the viewpoint from which this paper is written may be appreciated, it is desired to explain that the testing experience which is embodied has been obtained in the conduct of tests chiefly for the central stations which are members of the Association of Edison Illuminating Companies, and to a lesser extent in tests for certain railroads. It is through the courtesy of the Lamp Committee of the Association of Edison Illuminating Companies that the data presented in this paper are made available. The authors' viewpoint is that of the Electrical Testing Laboratories which acts as the agent of large lamp purchasers who have been studying the problem diligently for ten or fifteen years and whose purchases have grown year by year until during the past year they have aggregated about twenty millions of lamps.

*Paper before 1913 Convention Assn. Ry. Elec. Engrs.

Characteristics of Incandescent Electric Lamps

Rating.

In present-day manufacture the rating of Mazda lamps attains a higher degree of consistency than has been reached previously. A fair degree of uniformity is likely to be found among the lamps of any one package shipped from a factory. There are, however, some variations of the average of the group from the standard rating. The variation found in a typical group of lamps is about as follows:

Range in candle-power above and below average, five per cent.

Range in watts above and below average, two per cent.

Range in watts per candle above and below average, 3.5 per cent.

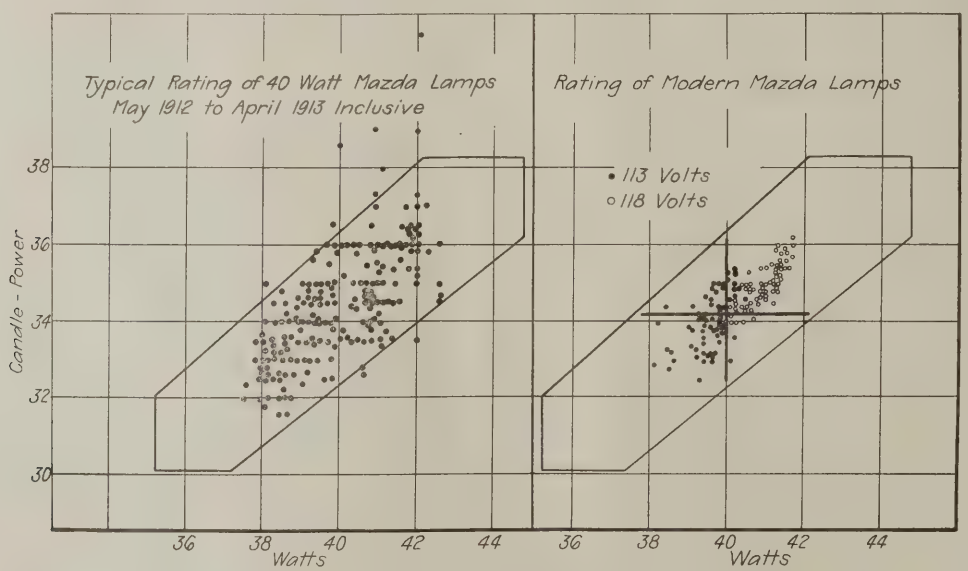

Fig. 1—Typical Rating of Multiple Mazda Lamps.

Figure No. 1 shows ratings of Mazda lamps of 1912 compared with those now found. These are lamps of the 110-volt range. The lamps one year ago were manufactured according to standard methods and each lamp was photometered in order to bring it as near as the factory photometry methods would permit to the rated watts-per-candle. The lamps represented in the right of the diagram were manufactured according to improved and better standardized methods and were prepared for shipment without photometry, reliance being placed upon the manufacturing method to produce lamps of uniform candle-power and efficiency. It will be observed that the more recent method results in a higher degree of uni-

formity, thereby producing more satisfactory lamps for the purchasers.

Physical Characteristics.

Defects in incandescent lamps, other than those which influence rating, may be divided into two classes:

(a) Defects which reduce life.

(b) Defects which render the lamp otherwise objectionable.

Considering first the defects of the second class, it will be noted that these are chiefly irregularities which render the lamps objectionable from the appearance standpoint. These are naturally of lesser importance to a purchaser who employs the lamps in his own service. While any purchaser is likely to desire lamps which present a good appearance, it makes little difference to the purchaser who employs the lamps in his own service if the filament spider is irregular or the brass base is tarnished, as long as the life performance remains unaffected. The case is different, however, when the lamps are not to be employed in the purchaser's immediate service. The central station, for example, sells the lamps to customers or gives them to the customer as a part of its service. The central station desires therefore not only that the lamps shall be of good efficiency and good life, but also that their appearance shall impress the casual customer favorably.

The problem from the railroad standpoint is probably concerned chiefly with those lamp defects which influence lamp life. These may be classified as fixed or graded, depending upon their influence upon the value of the lamp. Certain defects do not admit of degree and an unqualified decision may be reached as to the action which should be taken whenever they are found in a product. Thus breakage of the entire lamp or of any part of the lamp which renders it inoperative leaves no question as to the action which should be taken. The only question is as to the presence of the defect. The defect exists in the lamp or it does not exist. The one problem presented is, whether or not the best interests of the purchaser are served by rejecting a lamp thus defective, and the criterion is based simply upon the influence which the particular defect exercises upon the life of the lamp.

Defects of the second group admit of degree, and action taken with respect to one degree of the defect may well be reversed in the case of a lesser degree. A few instances will be given of defects of this nature. These for certain reasons are confined very largely to defects of the past, which no longer constitute problems in lamp testing.

When the metallized carbon or Gem lamp was introduced it presented a number of new problems not encountered to any great extent in tests of the treated carbon filament lamp. Prominent among these was the question of the vacuum criterion which should be adhered to. Following the practice upon which all lamp inspection should be based, quantities of lamps having slightly low vacua of a certain kind were selected and classified carefully with respect to degree of vacuum. These were then subjected to life test at normal efficiency in order to determine the influence which each degree of vacuum had upon the useful life of the lamps. The results are indicated in Figure 2. In the scale of ordinates, 100 per cent is the average useful life of all lamps of the types representing the period of manufacture which was contemporaneous with that of the low vacuum lamps on test. The differences between the curved lines and the horizontal 100 per cent line is the life depreciation found for each degree of low vacuum. With the results of this test available it was possible to determine intelligently the vacuum criterion which should be adhered to in accepting or rejecting Gem lamps, and as indicated on the diagram it was found that this criterion had to be increased considerably over that which had been found reasonable for treated carbon filament lamps. In other words, a

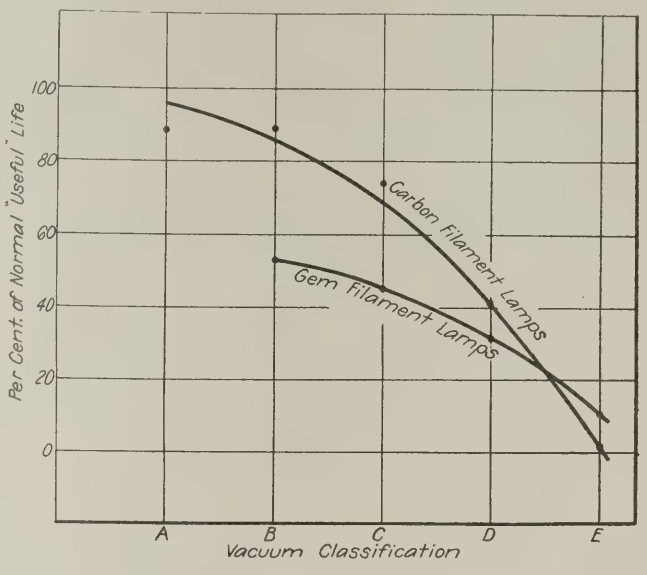

Fig. 2—Graded Defect—Life of Poor Vacuum Lamps.

degree of low vacuum which was satisfactory in treated carbon filament lamps proved deleterious in metallized carbon filament lamps of the same wattage.

Similar investigations were the basis upon which vacuum criteria were established for the various sizes of carbon and Gem lamps. Through these means it was found that a degree of low vacuum acceptable for one size of lamp of a certain type might be unacceptable for a lamp of the same type of a different wattage. Vacua of

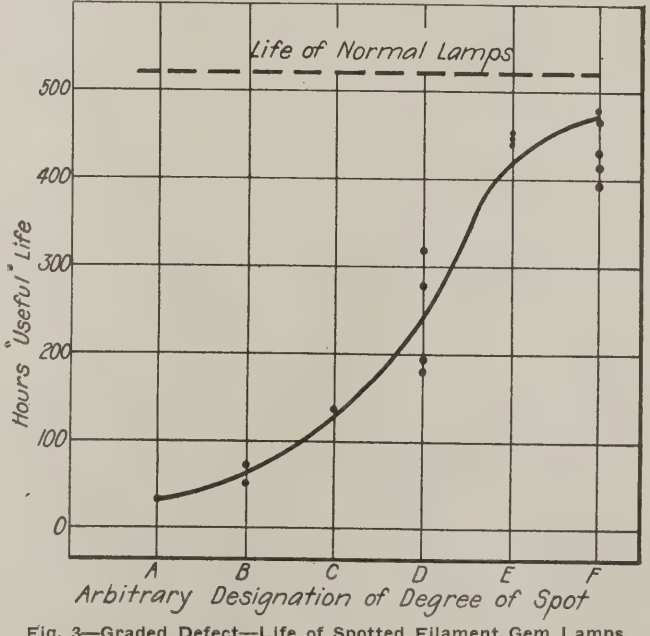

Fig. 3—Graded Defect—Life of Spotted Filament Gem Lamps.

different degrees are among the best illustrations of that class of defects which must be graded if inspections are to be applied intelligently in lamp testing. (In passing, it should be noted that some gases in Mazda lamps of certain types of construction do not depreciate the value of the lamps.)

It is known that if a small portion of a filament has a higher resistance than the remainder of the filament this small spot will appear brighter by comparison, and as the

lamp continues to burn the difference in brightness will become more apparent, due to the increased rate of filament deterioration at the high resistance point, which of course increases the temperature at that point. The presence of a "spot" of this kind shortens the life of a lamp. This defect affords another illustration of faults of the graded class. Its influence upon the life of metallized filament lamps is illustrated in Fig. 3. As in the case of the vacuum investigation, lamps with spotted filaments were selected and classified according to degree of brightness of spot. Life tests were made, rated efficiency, with results as shown. The life of normal lamps of the type investigated was 520 hours at the time the tests were made. Lamps having spotted filaments of a degree designated by A reduced this life to 30 hours. Spots of the degree C reduced the life to about 130 hours; spots of the degree E reduced the life to about 420 hours. Spots of the degrees E and F which depreciated the life by approximately 20 per cent were practically impossible of detection by ordinary inspectional methods.

The Mazda lamp product has hardly emerged from the development stage. Some forms of construction are as yet too new to be thoroughly known by even the most expert lamp inspectors. Defects which depreciate the life of the lamp largely have been found in Mazda lamps by special inspectional methods although beyond detection through ordinary inspectional methods. Other defects have been found which are not apparent at the time of inspection of the new lamps, but which become apparent after the lamps are put into service. In these and other cases, where lamp testing is undertaken provision should be made first, for the detection of the defect, second, for life tests to determine its influence upon the life of the lamp, and third, for co-operation with the manufacturer calculated to effect its elimination from the product in so far as may be practicable. The study of lamp defects by these methods is costly and occupies a good deal of time, yet it is the only means through which lamp inspections can be rendered intelligent and thoroughly effective. Inspections should be based not upon beliefs or hearsay evidence but upon facts.

Principles of Acceptance—Rejection

The writers know of only three purposes to be served by the rejection of lamps. These are (a) the elimination of defects located by sample inspections; (b) the elimination of corresponding defects from the lamps represented by the samples but which the sample inspections do not locate; and (c) the improvement of the product as a whole.

Consider the unit cost of incandescent lamps and the improvement in quality which may be effected as the result of inspections. In ordinary circumstances it is uneconomical to inspect more than a small percentage of the lamps in a given shipment. The problem, therefore, becomes one of rendering a sample inspection as effective as can be. Sample tests of a variable product are always likely to prove misleading, in consequence of the selection of non-representative samples. In lamp testing work this is likely to be the case unless the aggregate number of samples considered is large. It is doubtful if the rejection of a single package of lamps, based upon the test of such samples which it is economical under ordinary circumstances to select from that package, is ever justifiable.

Some years ago it was general practice to reject packages of lamps as a result of the detection of unacceptable individuals among the samples investigated. Although inspectional practice tends away from the old method and toward a more logical method, yet the evils of the old practice are still encountered and it may be worth while to consider for a moment what happens when a small number of samples are relied upon as a basis of acceptance or rejection of lamps. Let us assume that the manufacturer has prepared ten packages of lamps of a given size and type for submission to the purchaser's representative for an acceptance test. Let us assume that each package contains 200 lamps and that the inspector selects ten lamps from each package at random for test. Assume further that three per cent of the lamps are badly rated as judged by the purchaser's specifications. There are then 2000 lamps of which 60 are badly rated. The purchaser's agent selects 100 lamps for test. He finds all of the lamps in each of eight sample groups of 10 lamps to be rated acceptably. In one of the other groups there is a single lamp badly rated, and in the tenth group there are two lamps badly rated. The inspector rejects the package which is represented by the tenth group and accepts the other nine packages, culling out the single badly rated lamp which was found. The rejected package is replaced by a new package, presumably of the same rating characteristics as the other packages in the group. The chances are that the inspector does not find in his small group of samples one of the badly rated lamps in this package and he therefore accepts it. The 2000 lamps are shipped to the purchaser.

These 2000 lamps contain three per cent badly rated lamps less the single lamp which the inspector has removed from them. That is, they contain 59 badly rated lamps. If instead of rejecting the one package at the factory the inspector had rejected the two lamps which he found to be badly rated, had replaced them by well-rated lamps, and had then accepted the package, the following advantages would have accrued:

1. Instead of allowing the shipment of 59 badly rated lamps only 57 badly rated lamps would have been shipped.
2. The inspector's time in testing the additional package would have been saved.
3. The manufacturer's cost in handling the additional package would have been saved.
4. The factory people would have a larger respect for the purchaser's inspectional method, and would be more inclined to co-operate in making the inspections effective than is the case when the package is rejected irrationally.

This hypothetical case is illustrative of developments in the practice of rejecting large groups of lamps upon the performance of a few samples. The principles which the writers' experience emphasizes as being wise and constructive and to the best interest of the purchaser, and incidentally of the manufacturer, are indicated in the following precepts:

Group as many lamps as possible of one size and type and consider them as a whole, combining all the samples which have been tested or inspected.

If the percentage of defective or badly rated lamps in such samples is not abnormally large, accept the entire group, rejecting the unacceptable individuals which are found.

If the percentage of defective or badly rated lamps is abnormally large determine by inspection of additional samples from a few of the packages whether the objectionable feature is peculiar to certain packages or is found throughout the entire group in the proportion indicated.

If the former, reject the unsatisfactory packages.

If the latter, call up the manufacturer for a re-inspection of the entire group of lamps for the defect criticized.

In the formation of inspectional criteria co-operation with lamp manufacturers is advised. If the purchaser's

criterion with respect to any defect is more severe than that which the manufacturer maintains, but little advantage is derived from its application in sample tests. Lamps defective or irregular in any respect upon which the purchaser and the manufacturer are not agreed are shipped to the purchaser at least among the product which the purchaser's inspector does not inspect. Assuming that the purchaser's more severe criterion is correct and that the manufacturer's less severe criterion is incorrect, the inspector can benefit his own product more materially by persuading the manufacturer to increase the rigidity of his standard slightly, thus affecting the entire shipment, than he can by applying his own much more severe criterion of the few samples which he inspects. And incidentally, if the inspector succeeds in raising the manufacturer's standard of inspection he not only benefits his own product but also that shipped to other purchasers.

The three important purposes to be served by acceptance tests are:

(a) Securing the best attention of the manufacturer in the preparation of the lamps.

(b) Eliminating defective lamps which may be found in the product.

(c) Making available report data which give assurances as to the quality of the lamps when they are satisfactory, and which are a valuable means of safe-guarding quality in subsequent purchases when the data are properly applied by the purchaser in his negotiations with the manufacturer.

The writers have observed among lamp inspectors a tendency to concentrate so much attention upon the elimination of defective lamps from the samples which they examine, as to obscure the larger and more important purpose of influencing the manufacturer to eliminate undesirable lamps more thoroughly.

Life Performance

It is in connection with the non-uniformity of life performance of incandescent lamps that the greatest purchasing and test problems arise. The life of a given lamp varies rapidly with changes in voltage as encountered in either test or practice. The life of individual lamps of average quality varies largely, due to small differences in the watts-per-candle of the individuals. The life of individual lamps of any group is inherently variable, due to differences in the qualities of the lamps themselves.

Considering first the variation in life of a given Mazda lamp, with change in voltage supply, it will be noted in Fig. 4 that an increase of one per cent. in the voltage reduces the life by about 12 per cent. and that an increase of 5 per cent. in the voltage or of 1.5 volts in a 30-volt system, involves a reduction in life of about 46 per cent. This emphasizes the need of good regulation in practice and the necessity for extremely fine reglation of the voltage in life testing work.

Advantage has been taken of the sensitiveness of lamp life to changes in the voltage or efficiency, to conduct tests at high voltage in order to secure test results more speedily and reduce the cost of the test. Lamp engineers find forced tests of this character to be of great assistance in indicating the general value of the lamps produced from day to day, but they look to tests at normal efficiency for the final evaluation of a product. Among carbon filament lamps, moderate increases in efficiency for test purposes were approved under certain conditions, and after considerable experience the interpretation of such data could be made with fair accuracy. Among metalized carbon filament lamps, interpretation factors proved somewhat less reliable, and forced tests were not regarded quite so highly. Among modern Mazda lamps, forced tests are regarded as unreliable. Frequent changes in details of construction, while the lamps have not yet emerged from the developmental stage, have in some cases invalidated the interpretation factors arrived at for Mazda lamps of earlier construction. The modification of the lamps by the introduction of bulb blackening preventives of various constituents, embodied in the lamps in several different ways, has introduced variables affecting the reliability of forced tests to such an extent that forced life testing of Mazda lamps is not now approved.

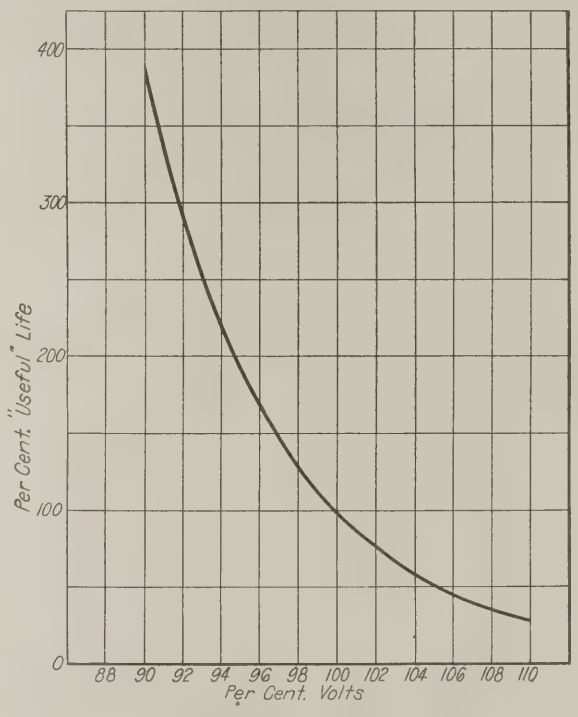

Fig. 4—Life Variations with Voltage—Mazda Lamps.

Results of a number of tests on lamps of different types at forced as well as normal efficiency are available. The ratio of life at forced test to that at normal has been compared to the computed ratio obtained from parabolic equations which have been published. The variations of the actual values from the theoretical ones taken from these correction curves are quite considerable in the case of the Mazda lamps as shown in Table I.

TABLE 1.

Life of Mazda and Gem Lamps. Forced Test in Per Cent of Normal.

Type	Theoretical Value	Actual Value	Variation Actual from Theoretical
60-watt Mazda	26.4%	23.4%	—11.3%
100-watt Mazda	31.6%	23.9%	—24.3%
100-watt (Different Getter)	31.6%	36.7%	+16.1%
250-watt	49.6%	27.4%	—44.8%
50-watt Gem	24.7%	23.8%	— 3.6%
35-watt Gem	31.3%	32 %	+ 2.2%

Forced tests are regarded as unreliable not only because of difficulty in interpreting their results to obtain their performance at normal efficiency, but because various features of performance may manifest themselves at the higher efficiencies which do not appear at normal efficiencies, or may be encountered at normal efficiencies to an extent not indicated when the lamps are burned at higher efficiencies. For example, in certain types of lamps, arcing across filament terminals has been observed at 0.9-w.p.c., when it does not occur in normal operation. Again, as a generality, it may be stated that the proportion of lamps which burn out during the period of 20 per cent. candle-power decline is smaller at

high efficiency than it is at low efficiency. Some data suggestive of this are given in Table 2.

TABLE 2.

Mortality During 20 Per Cent Candle-Power Decline.

Description of Lamp	——Normal Test—— Initial W. P. C.	% B. O. above 80% C.P.	——Forced Test—— Initial W. P. C.	% B. O. above 80% C.P.
25-watt Mazda	1.17	70%	0.90	50%
40-watt Mazda	1.12	44%	0.90	10%
60-watt Mazda	1.10	35%	0.90	15%
100-watt Mazda	1.07	8%	0.90	3%
50-watt Gem	2.50	13%	1.97	10%

Another variable of life performance is illustrated in Fig. 5 showing for two types of 110-volt Mazda lamps which are most largely used, variations in the average "useful" life of the lamps during a period in which the construction of these lamps was not changed materially. This shows variation in "useful" life of the 25-

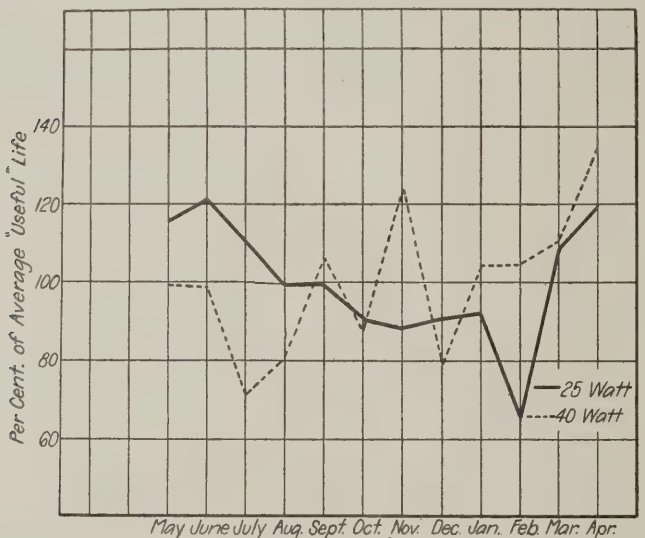

Fig. 5—Life Variations in Product—Monthly Basis.

watt lamps within a range of which the lowest point is only 54 per cent. of the highest. In the corresponding range for the 40-watt lamps, the lowest point is 53 per cent. of the highest. Considering these data as a whole, the indication is that a reasonably adequate determination of the average "useful" life of the lamps made during a given month in a given factory shows variations from month to month which average 16 per cent. If conclusions regarding the quality of a given product are based upon a test of a group of 30 lamps selected from the product during a given month, they may be 25 per cent. high, or 25 per cent. low if applied to the product of some other month.

Some of the variation of average values here noted may be due to test inaccuracies though every means has been taken to eliminate these. Some portion of the variation is traceable to actual variation in the average quality of the product. Another factor which enters into the variation is the inherent variability of the lamps made at any one time; that is, the differences in quality of the individual lamps which make up a given product. The extent of this variation is not generally appreciated. Among the lamps produced at a given time in a given factory under the best standardized manufacturing conditions, there is a large percentage of which the life is much shorter, and another large percentage of which the life is much longer than the average life of the entire group.

Fig. 6 illustrates this non-uniformity of life performance for carbon, Gem and Mazda lamps. The scale of ordinates shows life values in per cent. of the average "useful" life of the entire group which, incidentally, is more than twice as long for the Mazda lamps as it is for the carbon and Gem lamps. The scale of abscissae indicates the number of lamps in per cent. of the total number of lamps tested. Thus, referring to the light broken line curve, which shows the life of 60-watt carbon lamps, it is possible to find the percentage of the lamps whose life is for example, 70 or 80 per cent. of

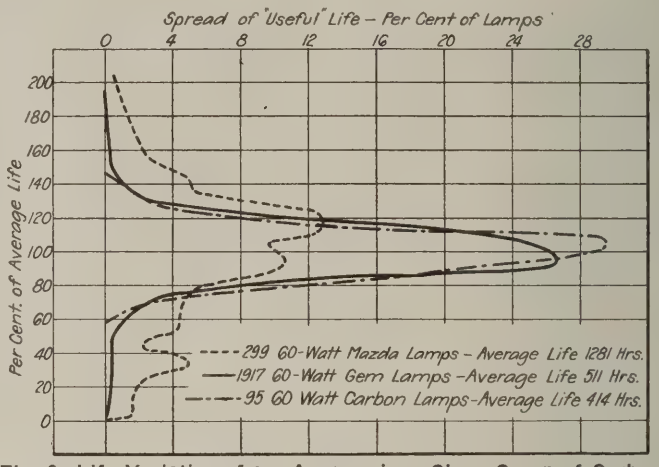

Fig. 6—Life Variations from Average in a Given Group of Carbon, Gem or Mazda Lamps.

the average life of all lamps tested. It will be observed that this curve indicates that there are a large number of lamps clustered closely around the average value and that there are practically no lamps which burned out below 60 per cent. or above 150 per cent. of the average "useful" life. The light continuous line shows the same data for Gem lamps, and it will be observed that a somewhat smaller percentage clustered closely about the average value, while there are more short lived and more long lived lamps. Among this type, lamps are found which burn out almost from the beginning of the test. The heavy broken line curve shows corresponding performance of Mazda lamps. It is evident that among the Mazda lamps there are many more short lived individuals than were found even among the Gem lamps, which in this respect were inferior to the older carbon lamps.

These data are believed to justify the statement that the incandescent lamp is among the most non-uniform products. This being the case, it is obviously important to select for a test a sufficient number of lamps to yield a fair indication of the average quality, and it is important to know how reliable the indication of the average of its samples is, assuming absolute accuracy for the test. Some data bearing upon this point are represented by the diagram shown in Fig. 7. In its preparation the test performance of 300 40-watt Mazda lamps of one type of construction, made in three factories during a given period, has been analyzed. The average useful life of these lamps was considered to be the true value for the "useful" life. Beginning with the first lamp, every thirtieth lamp was selected in order to obtain a group of ten lamps, and the deviation of the average value of this group from the true value was determined.

Beginning with the second lamp, the process was repeated, thereby securing a different group of ten lamps. A similar selection was made beginning with the third lamp and securing a third group of ten lamps and so on until thirty groups were available. The extreme variation of the average values of such groups of ten lamps from the true value is indicated in Fig. 7, the maximum positive variation being 21 per cent. and the maximum negative variation being 34 per cent. Corresponding selections were made to obtain as many groups of lamps as possible totaling respectively 12, 15, 20, 25, etc., with-

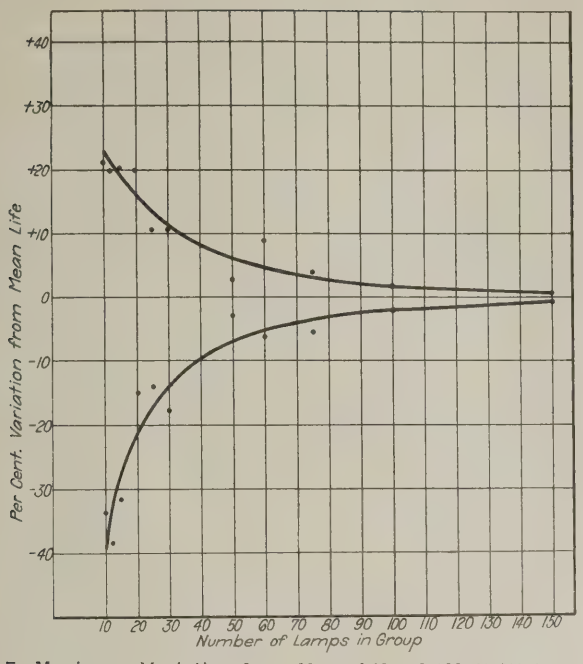

Fig. 7—Maximum Variation from Mean Life of 300-40 Watt Mazda Lamps, Grouped in Lots of Various Sizes.

out, of course, using any individual lamp in more than one group. The points shown upon the diagram are in all cases maximum variations from the true value encountered for the average life values of the groups indicated. A probable curve is drawn through the points thus determined, and it is considered to establish the limits within which tests of lamps in groups of stated sizes may not be considered reliable because of the non-uniformity of the individual lamps. This includes such non-uniformity as arises from differences in average quality which occur from time to time, and of course assumes most accurate practicable testing methods by which test inaccuracies are minimized. Within the limits indicated by these curves for groups of different sizes, well conducted tests of 40-watt Mazda lamps may be considered reliable, often attaining much more closely to the true value than is indicated by the curve. But where nothing is available beyond the average value of a test of a group of say 15 lamps, it must be remembered that groups of 15 lamps have sometimes yielded values which varied from the true average by as much as + 20 and —28 per cent. and that there is a chance that the average value may be misleading to any extent within these limits. When comparing two different makes of lamps through tests of groups of 15 samples of each product, it must be remembered that there is a chance that one group may be 28 per cent. lower than the true value, of the lamps which it represents, and the other may be 20 per cent. higher than the true value. These extreme possibilities of misleading results might therefore show for two products of equal value, results which would indicate that one product is 67 per cent. better than the other.

The subject of life tests should not be left without a reference to some of the remarkable improvements wrought in the life of Mazda lamps in the recent past. Fig. 8 shows the life values of 250-watt Mazda lamps selected as samples from among lots purchased by large central stations during the past two and a half years. In the spring of 1911 the life of these lamps at 1.13 watts per candle was in the neighborhood of 700 hours. In the fall of the same year by the introduction of bulb blackening preventive the life was increased to 1,400 hours. Later on account of the improved quality, it was possible to increase the efficiency, the watts per candle being reduced to 1.10, without detriment to the life. In July, 1912, another change of construction increased the life value to over 2,000 hours. In September of the same year the efficiency was very materially increased, the lamp being reduced to a one watt per candle basis, but as this change was coincident with another improvement in the type of construction, there was no material effect on the life. In the spring of the present year, still further changes in construction have produced lamps which have a life of 2,500 hours at one watt per

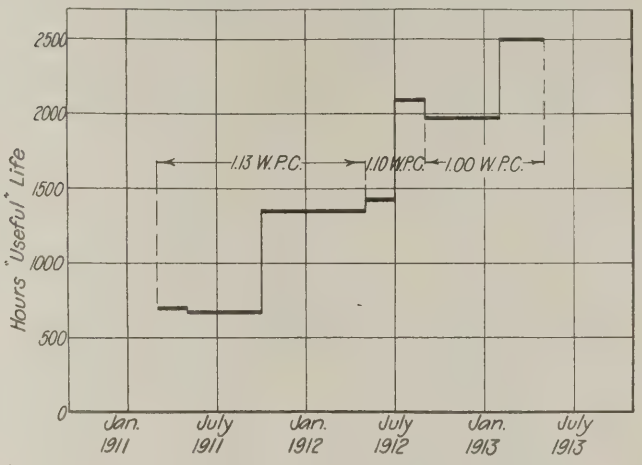

Fig. 8—Improvement in Useful Life Since 1911, 250-Watt Mazda Lamps.

candle. It is to be understood that these life values are considered as the hours to 80 per cent. or earlier failure.

Summary

The manufacture of lamps in this country is well standardized, and, compared with the practice of some years ago, and with practice abroad, is conducted on a high plane; good rating, careful selection and high quality are important desiderata in the eyes of the lamp manufacturers.

Because of this fact, haphazard, inexpert tests can accomplish nothing material in the improvement of the lamps purchased or in the establishment of superior purchasing methods. It has been shown in this paper that the peculiarities of the lamp testing problem are such as to demand a high order of specialization on the part of those conducting the tests. Well designed, carefully conducted, extensive tests, based upon definite knowledge of the peculiarities of lamps and of the effect of the defects which are encountered in lamps, can be made of effective assistance in lamp purchasing and can be relied upon to improve the product. Such tests, however, are costly. Experienced inspectors and testers must be available; the work must be supervized by a competent engineer; the statistical work must be done intelligently. The apparatus necessary to the conduct of life tests, without which lamp testing can never be made effective, is expensive. The cost of the lamps and of the carefully regulated current with which to operate them during life test is material.

If lamp testing is undertaken, a sufficient number of samples of each important class ought to be tested to determine with fair accuracy the value of the product once each month, and a similar determination ought to be made at least once each year for the lamps which are employed in lesser quantities.

It is the authors' conclusion that effective lamp testing can be done economically only when the purchases of lamps are very large. Smaller purchases of lamps cannot be tested independently in a manner which will secure effective results unless the cost is prohibitively high.

Centralized Control System for Panama Canal Locks

The electrical specification, design and manufacture of the Panama Canal centralized control system may properly be regarded as one of those undertakings which, from an engineering standpoint, not only arouses a lively interest but also presents an opportunity for much valuable instruction. The interest results mainly from the immensity of the Canal project itself, and the instruction from a consideration of the methods employed to insure the passage of even the largest ships afloat across the Isthmus with speed and safety. The complete operation of the Canal locks, terminals and auxiliary equipment utilizes electrical energy throughout, with the present exception of the Panama Railroad, the electrification of which is under contemplation.

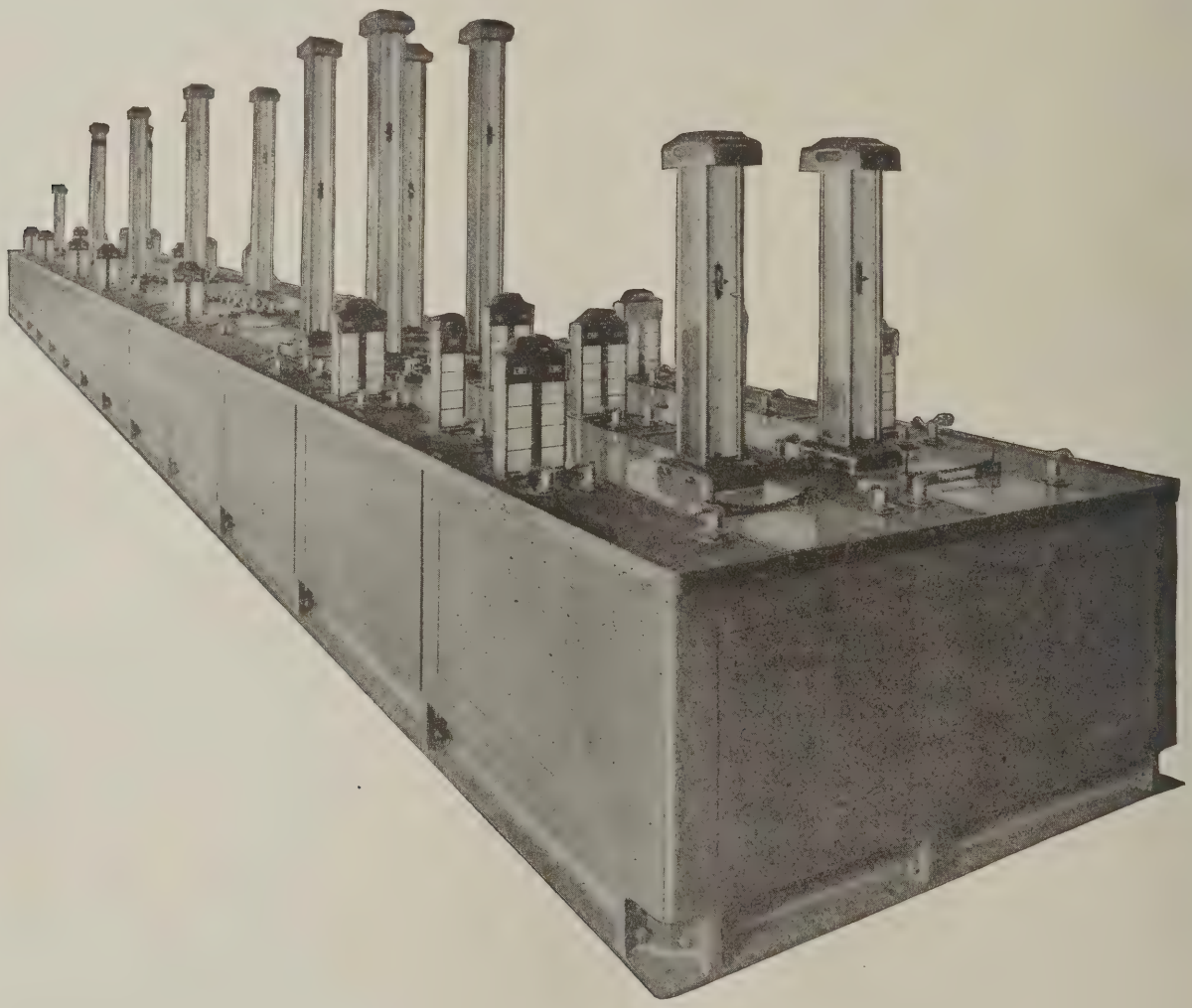

Fig. 1—Control Board for Miraflores Locks.

Generation and Distribution.

The power system for the operation of the locks, towing locomotives, lights for the locks and buildings, and motors not directly connected with the lock control, is composed of:

A 7500 kv-a, 2,200 volt hydroelectric power plant at the Gatun Dam;

A 4500-kv-a, 2,200 volt Curtis turbo-generator electric power plant at Miraflores for emergency, lately used to supply power for construction work;

A double 44,000 volt transmission line across the Isthmus, connecting Cristobal and Balboa with the two power plants;

Four 44,000-2,000 volt substations, stepping down at Cristobal and Balboa, and up or down at Gatun and Miraflores, depending on which of the two plants is supplying power;

Thirty-six 2,200-240 volt transmission stations for power, traction and light at Gatun, Pedro Miguel and Miraflores locks;

Three 2,200-220 volt transformer stations for the control boards at the locks;

Stations at Cristobal and Balboa for coal handling plants, machine shops and dry docks.

The system of connection throughout employs a double bus, double switch scheme, with provision for disconnecting any oil switch for cleaning or repairs without interrupting the circuit. In the power house and the four 44,000-2,200 volt substations, the oil switches are solenoid operated and are installed in concrete cells, above which are concrete fireproof compartments containing the two sets of buses. In the thirty-six transformer stations in the lock walls, the oil switches are hand operated. All 2,200 volt oil switches have disconnecting

switches, so arranged that live parts are completely covered. When the oil switch is lowered, it is completely isolated to a fixed circuit; when it is raised, it always goes to a fixed height where it is latched. An interlock prevents the oil switch from being raised or lowered unless its contacts are open, precluding the circuit being

Fig. 2—Control House on Center Wall of Upper Locks.

closed or opened by the disconnecting switch. In some instances another interlock makes two single-throw switches a double-throw switch and prevents both switches being closed at the same time.

Power Supply and Control Panels for Lock Machinery Motors.

Current for the lock machinery and towing locomotives is transformed from the 2,200 volt system. There are a total of thirty-six transformer stations, for all locks, each containing duplicate 200 kv-a, 3-phase, 2,200-240 volt transformers for power and one single-phase 25 kv-a, 2,200-220-110 volt transformer for lighting. The stations, normally fed from the 2,200 volt buses in the 44,000-2,200 volt substations, can also be operated from the power plants; the stations at Gatun locks from the Gatun hydroelectric station; and the stations at Miraflores and Pedro Miguel from the Mariflores emergency steam plant.

To give an idea of the number and sizes of motors to be controlled in operating the lock machinery, the following table is interesting:

Machines and Operation	Motors, each Machine and h. p.	—Number of Motors— Gatun.	Ped. M.	Mira.	Tot.	Total Horse Power.
Miter gate, moving, each leaf	1—25	40	24	28	92	2,300
Miter gate, miter forcing	1— 7	20	12	14	46	322
Fender chain, main pump	1—70	16	16	16	48	3,360
Fender chain, operating valve	1— ½	16	16	16	48	24
Rising stem gate valve	1—40	56	24	36	116	4,640
Cylindrical valve	1— 7	60	20	40	120	840
Guard valve	1—25	6	6	6	18	450
Auxil. culvert valve.	1— 7	4	4	4	12	84
Totals		218	122	160	500	12,020

There are many motors not included above, as, for instance, those for the spillway gates, for the hand rails on the mitering gates and for the sump pumps.

The motors are started and controlled by contactor panels located near them, the contractors of which handle the main motor currents. These contactors are controlled from the central control house. Two double-pole contactors are used, one for forward and one for reverse. In the case of larger motors for miter gate moving, rising stem valves and guard valves, a starting point with resistance in two legs of the three-phase circuit is provided. In all cases the contactors are operated from the control boards—to be described later—by three wires, one for forward, one for reverse and a common return. The control connections are arranged in such manner that each individual machine may be controlled locally. This arrangement provided for emergency operation should the control circuits from the central house be out of order.

From an operating standpoint the machinery was placed below the coping of the lock walls, thus affording a clear space for maneuvering ships and protecting the apparatus from the weather without erecting numerous houses.

The chain fenders are stretched across the canal in front of all mitering gates, which can be exposed to the upper lock level and also in front of the guard gates at

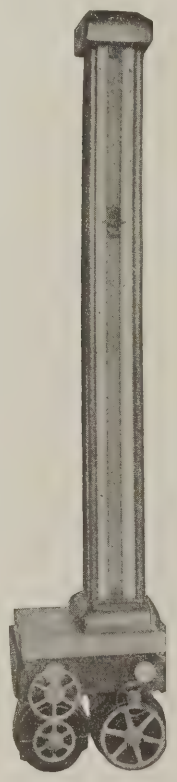

Fig. 3—Water Level Indicator.

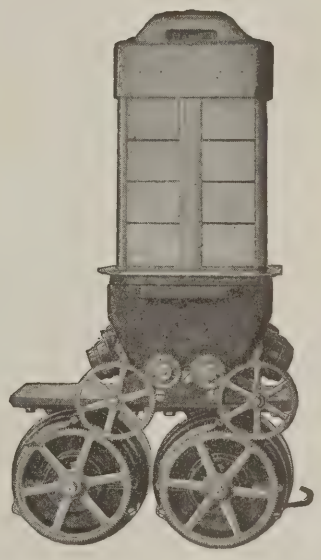

Fig. 4—Rising Stem Valve Indicator.

the lower end. These chains are maintained in a taut position when the gates behind are closed, and are lowered when the gates are opened for the passage of a ship. The chains are raised and lowered by a method similar to that followed in hydraulic elevators, with the additional features that if a ship approaches the gates at a dangerous speed and rams into the chain, the chain is paid out in such a way as to gradually stop the ship before it reaches the gates.

The filling and emptying of the locks is accomplished by three culverts, one in the middle wall and one in each side wall, the flow of water being controlled by rising stem valves. They are located in the culverts at points opposite each end of each lock so that the culvert can be shut off at any desired point for filling a lock with

water from above, or upstream, or for emptying it by allowing it to flow out and down to the next lock.

The rising stem valves are installed in pairs, and each pair is in duplicate; also each culvert is divided into two parallel halves at these valves by a vertical wall. This arrangement reduces the size of each valve and makes it more easily operated, each valve being 8 by 18 feet. One pair of duplicates is left open as a guard, or reserve pair; the other pair is used for operating, so that in case of an obstruction in the culvert or accident to the machinery, the duplicate pair can be used.

Centralized Control and Indicating System.

As the flight of locks at Gatun, for instance, extends over approximately 6,200 feet, and the principal operating machines are distributed over a distance of about 4,000 feet, it can be readily seen that central mechanical transmission of control of machines would be almost impossible; and to control the machines locally would mean a large operating force distributed practically along the full length of the locks, which has invariably been the practice heretofore. Such a force would be difficult to co-ordinate into an efficient operating system. The situation therefore resolves itself into centralized electrical control, which reduces the number of operators, operating expense, and liability to accident. To accomplish this system of control, a control board for each lock was constructed which permitted having all control switches located thereon mehanically interlocked so as to minimize, if not entirely prevent, the errors of human manipulations.

The control boards are installed in control houses located on the middle walls at points which afford the best view of the locks, although this view is not depended on to know the position of the gates or other apparatus, as all are provided with indicators on the control board. The control boards are made approximately operating miniatures of the locks themselves, and are arranged with indicating devices which will always show the position of valves, lock gates, chain and water levels in the various lock chambers; and with the exception of such machinery as needs only an "open" or "closed" indication, the indications will be synchronous with the movement of the lock machinery.

A complete synchronous indicator consists of a transmitter located at and operated by the machine in the lock wall, and a receiver operating an indicator at the switchboard in the control house. Both transmitter and receiver have a stationary and a rotating part. The stators have three-phase windings with leads from three corresponding equidistant points brought out and connected together, but not connected to a source of power, the stator coils being energized by induction from the rotors. The rotors are bipolar and are connected in multiple and energized from a 110 volt 25 cycle single-phase source.

The movement of the lock machinery and with it the connected transmitter rotor produces a field in the transmitter stator polarized in the direction of the rotor axis, which induces voltage in the stator coils. This voltage is transmitted by the three-phase connection above mentioned to the receiver stator coils and duplicates in them but in the reverse direction, the same condition of polarity and voltage as present in the transmitter. The rotor of the receiver being energized by the eternal source in the same direction as that of the transmitter, is reacted upon by the polarized receiver stator until the magnetic axes coincide and the rotors of both transmitter and receiver are in the same relative position. Any difference in the position of the transmitter and receiver rotors causes a difference of potential between the stator windings with a consequent flow of current and resultant torque, which again moves the receiver rotor to the same relative position as that of the transmitter rotor. The

Fig. 5—Interlocking System Under Control Board

receiver rotor follows closely and smoothly the movement of the transmitter rotor, and consequently imparts to the position indicator a movement identical with the movement of the lock machine, although on a scale reduced to the requirements of the control board.

The specifications covering the water level indication required an accuracy of 1/20 of a foot or 1/10 of 1 per

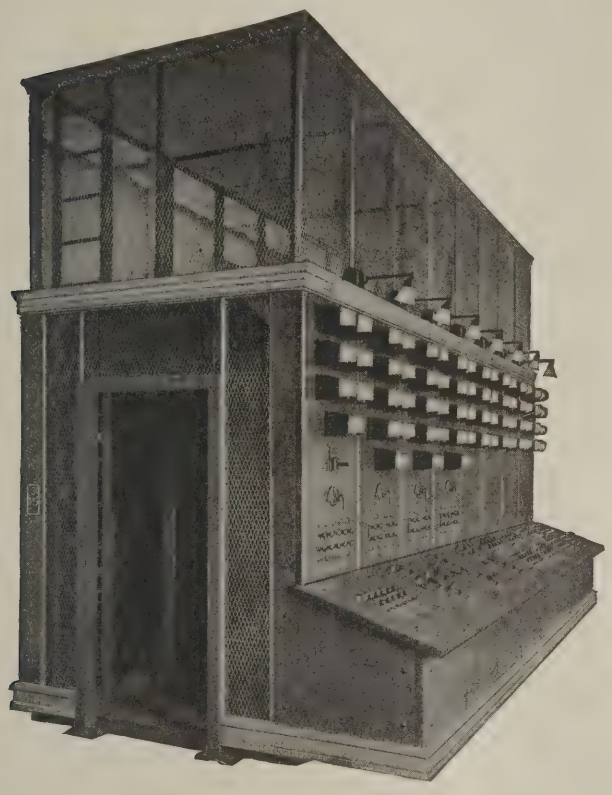

Fig. 6—2200 Volt A. C. Instrument and Control Board for Gatun Hydroelectric Station.

cent in actual water level. In the transmittors and receivers for the machines, described previously, the rotors turn less than 180 degrees with an inherent lag of 1½ per cent between transmitter and receiver rotors in this distance, which obviously prevents this arrangement from being employed to give the water level indication.

The control boards are of the flat benchboard type, 32 inches high by 54 inches wide, built in sections, with total lengths as follows:

Gatun	64 feet.
Pedro Miguel	36 feet.
Miraflores	52 feet.

The side and center walls of the locks are represented by cast iron plates and the water in the locks by blue Vermont marble slabs. The control switch handles are mounted above the surface of the board and operate through an angle of 90 degrees. They are provided with nameplates for the "open," "closed" and "off" positions.

In order to make it necessary for the operator to maneuver the control switch handles always in a certain order, corresponding to a predetermined sequence of operation of the lock machinery, and to prevent the operator in control of one channel from interfering with the machinery under the jurisdiction of the operator controlling the other channel, these control switches are provided with interlocks. The interlocks are in two vertical racks under each edge of the board and some distance below, so that they may be inspected and oiled from a floor which is about seven feet below the floor on which the switchboard operator stands.

To withstand the humid atmosphere of the Isthmus, every insulated part, such as solenoid, relay, circuit breaker and other coils, was impregnated with non-hygroscopic compounds. All small parts were made either of brass, copper, Moneal metal, bronze, or of sherardized iron or steel. Mica and treated asbestos lumber were used largely in place of fibre or wood.

The combined weight of the centralized control boards for Gatun, Pedro Miguel and Miraflores is about 39 tons. In their construction there is employed more than 2¼ miles of interlocking rod; about six million feet of control leads—made up in 5 and 8 conductor cables; 732 indicator motors; 464 control switches.

All of the lock machinery motors, control panels, centralized control boards, power station generating apparatus, switchboards, transmission line substation equipments, coaling stations, and practically the entire electrical equipment for the wharf terminal cranes and for the extensive permanent repair machine shops were manufactured by the General Electric Company.

PENNSYLVANIA RAILROAD TO PURCHASE ENERGY FOR PHILADELPHIA ELECTRIFICATION.

According to the present plans, before the end of 1914 all of the local trains between Broad street station, Philadelphia, and Paoli, and also between the Broad street station and Chestnut Hill, on the Pennsylvania Railroad, will be operated electrically; the first electric train out of Broad street station will be running by September next.

At the beginning it is contemplated to use about 4,500 horsepower, a minimum of 3,750 k. w., with a load factor of 25% being specified. The Pennsylvania R. R. has contracted with the Philadelphia Electric Co., to supply this power for five years, the railroad company reserving the right to increase its load at any time. The cost of this energy for the Paoli line alone will be approximately $150,000.

With the completion of the electrification already planned, the Pennsylvania Railroad will have 32 miles of electrified lines in the suburban district of Philadelphia.

NOVEL THREE-WIRE SYSTEM FOR NEW HAVEN ELECTRIFICATION

Although not officially announced, it is very probable that the extension of the electrified zone to New Haven on the New York, New Haven and Hartford R. R. will employ a novel application of the old three-wire system, used in d. c. lighting circuits. A voltage of 22,000 volts will be maintained between the adjacent trolleys of a double track system, the rails acting as the neutral of the three-wire system. The voltage to ground from each of the trolleys, however, will be simply 11,000 volts as now employed in the present electrified zone.

The advantage of such a system is at once evident, for with two trains of approximately the same load, both at a considerable distance from the sub-station or power house, the rail current back to the power house will be greatly reduced; in fact, eliminated, if the two loads are exactly balanced. As this balance will rarely occur, however, there will always be some current flowing in the rails or neutral connection. This, however, on the average will be greatly reduced over past operation. The two parallel tracks are to be heavily bonded together and heavy return leads run back to the power house.

Eliminating the rail current not only saves in the distribution losses, but it reduces to almost one-half the magnetic disturbances affecting telephone and telegraph systems paralleling the railroad.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

MAGNETISM.

No study of electrical engineering could be complete without a thorough study of magnetism, since much electrical apparatus is dependent upon magnetism for its action. In this pamphlet, magnetism only will be discussed, reserving for other instruction papers the very closely related subjects of (1) "Magnetic Effect of the Electric Current," and (2) "Electrical Effects of Magnetism."

1. Natural and Artificial Magnets.

Magnets are substances which have the property of attracting iron, and the term magnetism is applied to the cause of this attraction and the resulting phenomena.

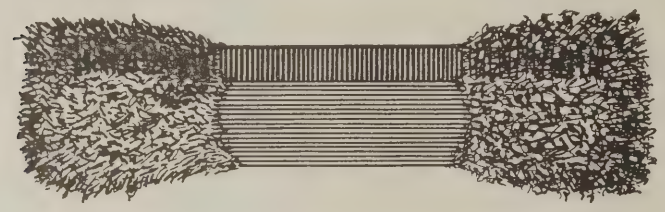

Fig. 1.

Magnetism was known to the ancient world. It sometimes exists naturally in pieces of an ore of iron, which is known to chemists as magnetic oxide of iron, or magnetite. This ore was first found at Magnesia, in Asia Minor, hence the name magnet. Loadstone, or "leading stone," is another name applied to a natural magnet.

When a bar of steel is stroked with a magnet, the bar itself becomes a magnet. Such bars are called artificial magnets. Magnets may also be made by means of the electric current. A bar of iron or steel may be wound with a coil of insulated wire, and will become a magnet when a direct current of electricity is passed through the coil. Very strong magnets may be made in this way. If a soft iron bar is magnetized by this method, it will be found that after the current is switched off from the coil the bar is no longer magnetic, or at best shows only very slight magnetism. A hard steel bar, however, will remain a magnet after being taken from the coil, and is, therefore, called a permanent magnet.

2. Poles of a Magnet.

When a bar magnet is suspended by a thread about its center, so that it swings freely in a horizontal plane, it will turn to such a position that one end points north and the other end south. The end which points north is known as the "north-seeking" or north pole of the magnet, while the end which turns south is termed the "south-seeking" or south pole. The north pole is also often called the positive pole and designated simply by a pluse sign (+), or "N," and the south pole is called the negative pole of the magnet, and designated by a minus sign (—), or "S." When the bar magnet is rolled in iron filings, the filings are attracted by the ends or poles and adhere to them, but few, if any, particles are picked up by the center of the magnet.

It is evident from this experiment that the greater part of the magnetic attraction is concentrated at the poles of the magnet.

3. Magnetic and Non-Magnetic Substances.

A magnetic substance, or technically speaking, a para-magnetic substance, is one which is attracted by a magnet, or which can be magnetized. Iron and its alloy, steel, are the chief magnetic substances, though nickel and cobalt (other metals) can be magnetized to a slight extent. Certain other metals, such as bismuth, antimony, zinc and lead, are slightly repelled by a magnet, and are, therefore, termed diamagnetic substances. Practically all other substances are not appreciably affected by magnets, and can, therefore, be called non-magnetic substances.

4. Insulators of Magnetism.

When a sheet of glass is placed in front of a strong magnet it will be found that the magnet acts through the glass without any apparent difficulty. In a similar way the magnetic attraction acts through all other materials except magnetic substances. In the case of iron or steel, the magnetic attraction acts on the metal instead of passing through it. Thus it will be seen that there is no material which will serve as an insulator against magnetism, though iron or steel will, in a measure, screen objects from it. Soft iron cases are sometimes used for watches to shield the works and prevent them from becoming magnetized.

5. Mutual Action Between Magnets.

Either pole of a magent will attract a piece of iron or steel. With two magnets of equal strength, it will be found that the north or "N" pole of one repels the north pole of the other, and the south or "S" pole of

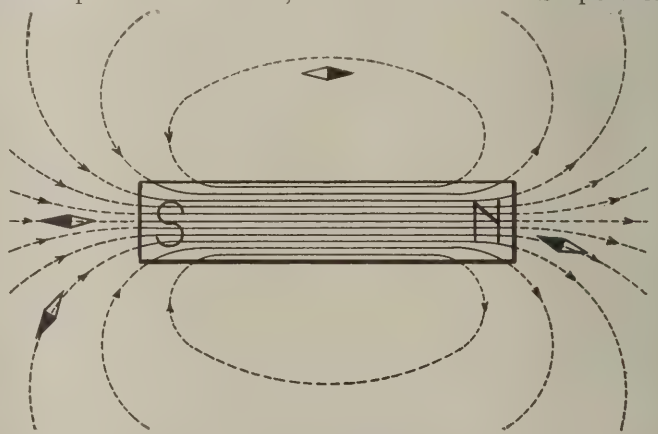

Fig. 2—The Black End of the Compass Needle is in Every Case the South Pole.

one repels the soult pole of the other, but the north pole of either one will attract the south pole of the other. This experiment illustrates a fundamental magnetic law, namely:

Like poles repel and unlike poles attract each other. By means of a suspended magnet the polarity of any other magnet may be readily determined, for the pole of the second magnet that repels the north pole of the suspended one is also a north pole.

6. The Magnetic Field.

The space about a magnet or magnet pole in which

the magnet can exert magnetic force is termed its magnetic field. This field extends in all directions about the magnet. For convenience, it is customary to consider the magnetic field to be made up of lines of magnetic force, which leave the magnet at its north pole and return at its south pole, passing through the magnet to the north pole and completing the circuit. The field of a magnet may be explored and the direc-

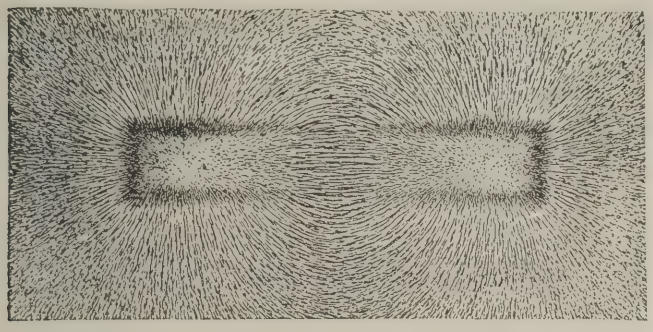

Fig. 3—Showing Magnetic Field About a Bar Magnet.

tion of the lines of force determined by means of a small pocket compass. When the compass is held in the magnet's field, the compass needle will assume a position parallel or tangent to the lines of force. The distribution of the lines of force about a bar magnet is roughly shown in Figure 2, and the position of a compass needle at various points in the field is indicated.

The black end of the compass needle is in every case the south pole.

7. Magnetic Spectra.

A better method of determining the distribution of the lines of force is by means of magnetic spectra, or diagrams. A sheet of glass or heavy paper is laid over the magnet whose field is to be reproduced, and

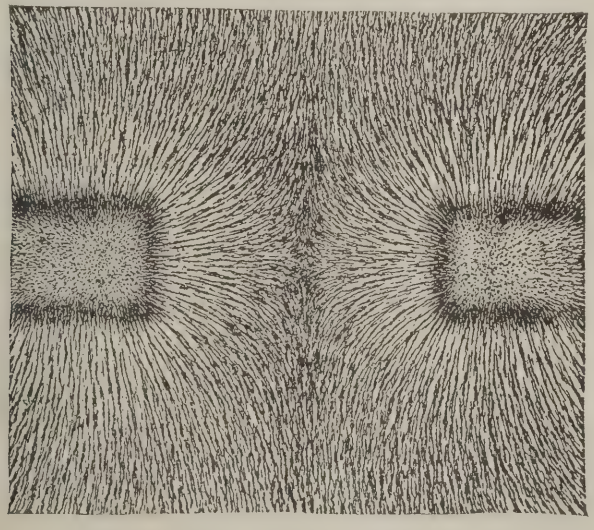

Fig. 4—Magnetic Poles N and N or S and S.

iron filings are sifted on it. Then the glass or paper is tapped lightly and it will be found that the filings arrange themselves in tufts and lines which indicate very clearly the direction and intensity of the magnetic field. Such a magnetic spectrum for a bar magnet is shown in Figure 3.

8. Study of Magnetic Spectra.

By a study of magnetic spectra many of the phenomena of magnetism are made clear. In Figure 3 it will be seen that the lines of force are concentrated at the edges of the magnet poles, and spread out over the field, their intensity growing less the farther they are away. If the diagram were large enough, and could show the actual lines of force instead of filings influenced by the force, it would be found that all lines leaving one pole ultimately curve around and enter the other pole. Each line of force constantly tends to shorten itself, and is repelled by the other lines beside it, so that the resulting curves are obtained. Another peculiarity attributed to lines of force is that they never cross each other.

In Fig. 4, which shows the magnetic field between two like poles, the bending over of the lines from the poles as they meet is clearly shown, and the repulsion between the two poles can readily be imagined.

Figure 5 shows the field between two unlike poles, and it will be seen that many of the lines from one pole continue to the other. Since the tendency of these lines is to shorten, the reason for the pull or attraction between the two can be seen.

Figure 6 shows the field between unlike poles, but

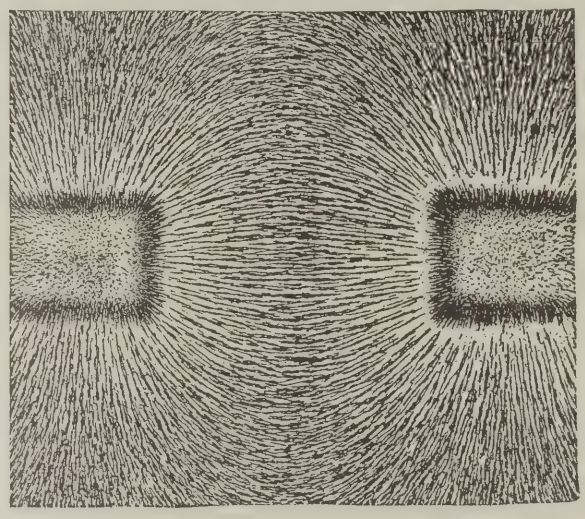

Fig. 5—Magnetic Poles N and S.

with a piece of iron placed between the two magnets. The distribution of the lines of force is considerably altered. The iron is a better conductor of the lines of force than the air space, and there is a convergence or bending in of the lines to it.

9. Induced Magnetism.

The iron filings used in obtaining magnetic spectra do not touch the magnets whose fields they represent, yet they attract each other and form into tufts and

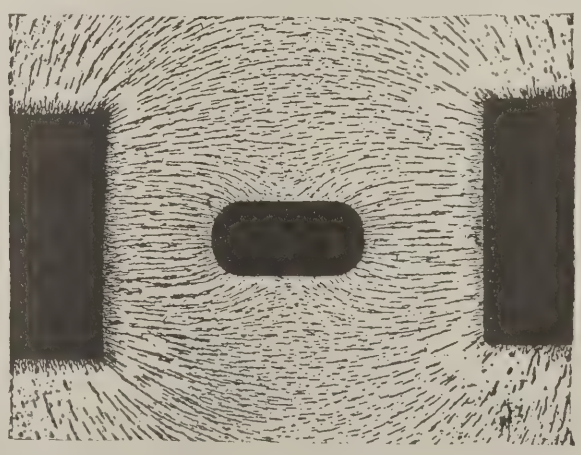

Fig. 6—Magnetic Spectrum with Iron In It.

lines under the influence of the magnetic field. In reality, each one of the filings has been magnetized by induction, and, while in the magnetic field produced by the large magnet, is a magnet itself. In a sim-

ilar way, the piece of iron between the magnet poles in Figure 6 is magnetized by induction.

10. Distributed, Concentrated and Isolated Poles.

It will be seen that, in the short bar shown in Figure 3, the lines of force leave and enter the magnet over a large area at the ends, extending well down to the center. Such a magnet is said to have distributed poles. If the length of the magnet is great compared with its cross-section, magnetic force will be appreciable only at the poles over a comparatively small area. Such a magnet is said to have concentrated poles. If the poles of the magnet are so far apart that their effect on each other is negligible, each pole may be considered separately as an isolated pole.

QUESTIONS.

First Lesson.

1.—Give two methods of magnetizing a piece of steel.

2.—A steel ball is plated with brass and enclosed in a leather case. Will it be attracted by a magnet brought near it?

3.—If you were given a bar magnet and a compass, how would you determine the north and south poles of the magnet?

4.—Two bar magnets are laid side by side as shown.
(*a*) Would they attract or repel each other?
(*b*) Make a sketch showing the distribution of the magnetic field about these magnets.

5. One of the magnets in question 4 is turned around, end for end.
(*a*) What difference does this make in the force between the two magnets?
(*b*) Make a sketch showing the distribution of the magnetic field.

6.—The magnetic pole at the left side of Figure 6 is a north pole. Make a sketch showing the location and sign (whether positive or negative, north or south) of all other poles in the figure.

7.—If a magnetic compass were placed between the poles of a horseshoe magnet, how would the compass needle behave?

8.—(*b*) What shape should a magnet have to best retain its magnetism?
(*b*) Of what material should it be made?

9.—A magnet of constant strength is required for a voltmeter. How should it be treated after magnetization to obtain this quality?

10.—Why does a compass needle take up a definite position on its pivot? Explain fully.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

As announced last month, the meetings of the Railroad Electricians' Club are devoted to a study of the lessons of the Pennsylvania School of Electricity as published in the *Railway Electrical Engineer*. We try to get right down to the bed rock foundation of things and present the subject in good plain English, which everybody can follow.

After a brief course of instruction, the problems published in our last issue were taken up and worked out. Later the Question Box was passed around and drew a number of practical questions from the railroad men present, which are published in this section. It is our purpose here to record as nearly as possible what happens at these meetings so that the thousands of men who are unable to attend the meetings may get the benefit of this course.

PROBLEMS.

(Better read over lessons No. 1 and 2 of the Pennsylvania R. R. School of Electricity, before studying these problems.)

Fifth Lesson.

Question 27. If a resistance of 1 ohm, and another of 2 ohms are connected in parallel, what is the joint resistance?

Ans. No. 27. We have found from the last lesson that conductivity of 1 ohm is 1 and the conductivity of 2 ohms is ½. With resistances in parallel, we simply add the conductivities, so the conductivity of these two resistances in parallel would be 1½ or 3/2. The resistance of the combination is then simply the reciprocal of this (fraction turned upside down), or 2/3 of an ohm.

Question 28. If 3 resistances are connected in parallel, one of 2 ohms, one of 4 ohms and one of 1 ohm, what is the joint resistance of the combination?

Ans. No. 28. The conductivity of 2 ohms is ½, of 4 ohms ¼, and 1 ohm is 1. The joint conductivity of the whole combination is the sum of all these, or 1¾, or 7/4.

To get the resistance of the combination we then simply turn this fraction up side down, which gives us 4/7 of an ohm as the joint resistance of these three resistances connected in parallel.

Question 29. How much current will a 15 horse power direct current motor take on a 110-volt circuit?

Ans. No. 29. One horsepower is 746 watts, therefore 15 horsepower would be 15 times this, or 11,190 watts.

A watt represents power and is the product of 1 ampere times 1 volt, so where we know the number of watts and the voltage, the current flowing is simply the watts divided by the volts.

With 11,190 watts at 110 volts, then we will have (11,190 divided by 110, or) 101.7 amperes current flowing.

Question 30. Suppose 10 tungsten lamps are connected in series for yard lighting, and one of these lamps burns out, what is going to happen to the others, and why?

Ans. No. 30. When lamps are connected in series the same current passes through all of the lamps. If any of these lamps burn out it will break the circuit and unless there is some automatic arrangement for short circuiting that particular lamp, no current can flow, and all lamps in the circuit will be dead.

Question 31. Why is hard drawn copper wire used for transmission lines and why is soft annealed wire used for interior wiring?

Ans. No. 31. Hard drawn copper wire is considerably harder and stronger than annealed copper wire, so it is much more desirable for use in overhead lines, where the wire is often subjected to great strain due to sleet storms, etc.

Annealed wire is much softer and more flexible than the hard drawn wire and accordingly, it is much better suited to interior wiring where the wire is bent a great deal, in pulling it through conduit, etc.

Question 32. Suppose you have a copper wire of ¼-inch in diameter, what number B. & S. gauge is it, and what is its resistance per thousand feet?

Ans. No. 32. The diameters of the various sizes of wires are given in column 2 of table No. 3, page 19, of our June lesson. These diameters are given in mils, one

mil being equal to .001 inch. ¼ in. is then 250 mils, so if we look under the table for the wire whose diameter is nearest 250 mils we find that a No. 2 wire is of 257 mils diameter, therefore, the wire in question must be a No. 2 wire. Its resistance per thousand feet is found under column 9 to be .156 ohms.

Question 33. Suppose you are buying wire from a foreign concern who measure their wire according to the N. B. S. standard, and you have a No. 8 N. B. S. wire, what is the nearest size on the B. & S. gauge, which is so generally used in America? (See table 4, lesson No. 1.)

Ans. No. 33. Referring to table No. 4, page 20 of the June lesson, we find under the sixth column that a No. 8 N. B. S. gauge is 160 mils in diameter and under column No. 2 we find that a No. 6 wire B. & S. gauge is 162 mils in diameter. Therefore, a No. 8 N. B. S. gauge is approximately the same as a No. 6 B. & S. gauge.

Question 34. Suppose you are buying wire from another foreign concern, which uses the B. W. G., or Stubs gauge, what should the micrometer be set at to check the diameter of a No. 4 wire? (See table 4, Lesson No. 1.)

Ans. No. 34. Under column 4 of table No. 4, lesson No. 1, we find that the diameter of a No. 4 wire is 238 mils, therefore, the micrometer could be set at .238 in. in checking the diameter of this wire.

Sixth Lesson.

Question 35. What is the relation between a volt, an ampere and an ohm?

Ans. No. 35. If we have a resistance of one ohm it will take one volt to cause one ampere of current to flow through this resistance. Similarly if we have 2 ohms resistance it will take 2 volts to cause one ampere of current to flow through the circuit, or if we have a resistance of ½ ohm with 4 volts impressed, there will be 8 amperes of current flowing.

Question 36. Suppose you have a resistance of 4 ohms across a 30-volt battery circuit, what will be the current flowing? What will it be if this voltage is increased to 40 volts?

Ans. No. 36. As explained under Ohms Law in lesson No. 1, page 15, June, 1913, issue, the current flowing is equal to the voltage divided by the resistance, so if we have 4 ohms across a 30 volt battery, the current flowing will be 30 divided by 4, or 7½ amperes. If the wire of this resistance has a zero temperature coefficient, so that its resistance does not change as the coil warms up, the current flowing when the voltage is increased to 40 volts would be the voltage divided by the resistance, 40 divided by 4, or 10 amperes. (The resistance of ordinary copper wire will increase as the coil heats up, so the current will be something less than 10 amperes, depending upon how much the resistance is increased.)

Question 37. Why don't we get the same voltage at the motor end of a power circuit when the motor is running under load, that we get at the generator end of this same circuit? Why does it vary when the load changes even though the voltage at the power station is absolutely constant?

Ans. No. 37. There is a certain loss in voltage when current flows through any wire, depending upon the amount of current and upon the resistance of the wire. When the motor is running under load, this voltage loss will reduce the effective voltage at the motor by a certain amount, and the greater the motor load, the more the voltage at the motor will be reduced. This explains why it is bad practice to operate motors and lamps from the same circuit, heavy fluctuations in motor current will cause serious fluctuations in lamp voltage.

Question 38. Suppose the load on a d.c. motor is doubled, how much more will the power loss in the line be than formerly?

Ans. No. 38. In question No. 37, we consider only the voltage drop in the line, while this question considers power loss, the difference should be carefully noted. The power of an electrical circuit is the number of volts times the number of amperes; therefore, the power lost in the line is equal to the number of amperes, current flowing times the number of volts drop in the line. But as we have seen from question No. 37, the voltage drop in the line increases with the current, twice the current will cause twice the voltage drop. Or in other words, the voltage drop is equal to the number of amperes times the number of ohms resistance in the line. The power lost is the number of volts times the number of amperes, but the number of volts is equal to the number of amperes times the resistance, therefore, the power lost is equal to the square of the current, (number of amperes times the number of amperes) times the resistance of the line. It is then evident that if the number of amperes taken by the D. C. motor at the end of the line is doubled, the power lost in the line will be increased four times.

Question 39. Why is it that whenever we transmit power any great distance we always operate the circuit at a high voltage?

Ans. 39. As we have seen from problem No. 38, the power lost in the line varies with the square of the number of amperes, that is, if the number of amperes is doubled, the power lost is increased four times; if the number of amperes is increased three times, the power lost in the line is increased nine times.

The power (number of watts) delivered to a D. C. motor or lighting circuit is equal to the number of volts times the number of amperes, therefore, 10 amperes flowing through a 440 volt motor would give the same power (10×440, or 4400 watts) as 40 amperes flowing through a 110 volt motor on a 110 volt circuit (40×110, or 4400 watts).

Therefore, if it is necessary to transmit the power any great distance it will be more economical to operate it at the higher voltage, for by cutting down the current to ¼, the amount of power lost in the line will be reduced to $\frac{1}{16}$ of what it was on the 110 volt circuit. On high voltage alternating current circuits this saving is even more pronounced.

Question 40. Suppose you have a yard charging line of 1/10 ohm total resistance in the outgoing and return circuit, and 40 amperes charging current flowing to the battery, the voltage at the power station is 50 volts. What is the voltage at the terminals of the battery?

Ans. No. 40. With 40 amperes flowing through a line resistance of $\frac{1}{10}$ of an ohm there would be a voltage drop in the line of $40 \times \frac{1}{10}$, or 4 volts; the voltage at the battery is then generator voltage minus the line drop (50 minus 4 volts, or 46 volts).

Seventh Lesson.

Question 41. We know that it takes two conductors to complete any electrical circuit. Why is it then that in street railway work only one trolley is used? How does the current get back to the power house?

Ans. No. 41. The rails form the return conductor to connect the motor with the power house on the negative side.

Question 42. Why do the telephone, gas and water companies complain about this? What can be done to overcome this trouble in a practical way?

Ans. No. 42. Since the rails through which the return current flows are embedded in the earth, there is considerable leakage of current from the rails into the earth and this earth current reaches the iron water and gas pipes, lead telephone cables, etc., and flows through them as they offer a path of lower resistance than the ground. If the trolley line leads away from these pipes and cables, however, the earth current leaves the pipes and cables and flows again into the earth, following the trolley line, or making a straight cut to the power house as the case may be.

Where the current leaves the iron pipe or lead cable, however, electrolysis occurs and this causes a chemical action to take place which eats away the lead or iron and soon pits the pipe or cable causing it to leak. This will

also occur at the joints between water pipes, where the electrical contact between pipes is not very good.

This can be largely overcome by heavily bonding the rails together so that a path of very low resistance will be offered for the current through the rails and similarly heavy copper cables for return may be connected to the rails at various points to tap off the return current and lead it direct to the power house. Even this, however, cannot completely eliminate the troubles from ground current.

Question 43. A telegraph circuit 16 miles between stations uses a No. 8 B. W. G. double galvanized iron wire. What is the total resistance of the circuit?

Ans. No. 43. Most all telegraph circuits consist of only one wire, using the ground connection at either end for the return. The problem is then to find the resistance of a No. 8 B. W. G. galvanized wire 16 miles long, the ground resistance offered to the return current being neglected. From table No. 5, page 20 of the June lesson, column 9, we find that wire of the BB, or medium grade has a resistance of 14.87 ohms per mile, the resistance for 16 miles of wire would then be 16×14.87, or 238 ohms.

Question 44. If two 300-ohm relays are connected in circuit with a 150-volt battery, as in problem 51, what will be the current flowing? If another relay of 100 ohms is connected in parallel with one of the 300-ohm coils, what will be the current flowing through the line?

Ans. No. 44. From problem 43 we found that the resistance of the line is 238 ohms. The two 300 ohm relays connected in series will make a total resistance of 600 ohms, which added to the 238 ohms of the line, will make a total resistance of 838 ohms in the complete circuit. If a 150-volt battery is then connected in the circuit, the current flowing will be the volts divided by the resistance (150 divided by 838) or .179 of an ampere.

If another relay of 100 ohms is connected in parallel with one of the 300 ohm coils it will considerably reduce the total resistance of the circuit. Consider for a moment simply the two coils in parallel, one of 300 ohms resistance, and one of 100 ohms resistance. The conductivity of the 100-ohm coil is 1/100 and that of the 300-ohm coil, 1/300; 1/100 may be written 3/300, therefore, when we add 3/300 to 1/300 we get 4/300, as the conductivity of the two coils in parallel. Now turning this fraction upside down gives us the resistance of the combination (300 divided by 4, or) 75 ohms as the joint resistance of the 100-ohm and the 300-ohm coils connected in parallel.

This when added to the resistance of the other coil (300 ohms) and that of the line (238 ohms) gives a total of 613 ohms total resistance. The current flowing will then be the voltage divided by the total resistance (150 divided by 613, or .242 of an ampere). In this problem we have neglected the resistance of the storage battery, but as the resistance is comparatively low, being but .025 of an ohm per cell, giving a total resistance for the battery of 150 times .025, or 3.75 ohms.

This Is On Us.

To the Editor:—

I am a subscriber to the Railway Electrical Engineer and wish to call your attention to what I believe is a mistake in explaining question No. 21, page 277, under the "Railroad Electricians' Club" in the December issue. My answer to this question would be as follows:

I would first find what current will flow through one lamp, wattage divided by the voltage (25 divided by 110, or .277 of an ampere). The resistance of one 25-watt lamp is then the voltage divided by the current (110 divided by .227, or 484 ohms.)

Now, then, if we place these two lamps in series, the total resistance would be the sum of the two individual resistances or 968 ohms. With this resistance on a 110-volt circuit, the current would be the voltage divided by the resistance, (110 divided by 968, or .114 of an ampere). Therefore, the current flow of such a circuit would be .114 of an ampere, and the resistance would be 968 ohms.

Trusting you will pardon the liberty I am taking, but as I am employed in electrical train lighting service, by the Northern Pacific Ry. Co. and find the *Railway Electrical Engineer* very interesting reading matter, I feel that for the good of the magazine I should call your attention to this matter.

Wm. P. Mulligan.

Editor's Note.

Editor's Note.

Fine work * * * it is mighty gratifying to be picked up on mistakes like this, for it shows us that the boys are studying this course and that our feeble efforts are not in vain. But we have to get out from under somehow or other, so hope you will notice that we worked this out for two 50-watt lamps in series instead of two 25-watt lamps, as the problem called for.

PROBLEMS FOR NEXT MONTH.

Eighth Lesson.

Question 45. What do you use to make up a gravity cell, and just how are these things put together?

Question 46. What is the voltage of a gravity cell?

Question 47. Why is it always used on closed circuit?

Question 48. What happens if the blue solution gets to the top of the cell? What causes this to happen, and what should be done when it does occur?

Question 49. Why is it necessary to place a rubber tube over the wire leading down to the positive copper plate in the bottom of the cell?

Question 50. Is a dry cell actually dry?

Question 51. What is the voltage of a dry cell?

Question 52. What is the difference between a dry cell and a gravity cell.

Ninth Lesson.

Question 53. Can a dry cell be used on closed circuit?

Question 54. Suppose you connect a condenser of 1 m.f. to a battery of 20 volts, then remove the condenser and connect it to a voltmeter, the electricity stored in condenser will discharge through the voltmeter, giving the needle a "kick" to, say 8 scale divisions, what is the capacity of another condenser which when connected with the same battery gives the voltmeter needle a kick of 16 scale divisions?

Question 55. Supposing a condenser is discharged by allowing it to spark, is this current simply a direct current flow, or is it an alternating current flow?

Question 56. If 2 condensers, each of 2 m.f. capacity, are connected in series, what is the capacity of the combination?

Question 57. If 2 condensers of 2 m.f. capacity, are connected in parallel, what is the capacity of the combination?

Question 58. Suppose you wanted to get a total capacity of just 7 m.f. and had nothing but condensers of 2 m.f. available how could you connect some of these up to get the required 7 m.f. capacity?

Tenth Lesson.

Question 59. How do you test a dry cell to see if it is any good?

Question 60. Why are dry cells used in door bell and telephone work instead of gravity cells?

Question 61. What is meant by polarization? Does this occur in a gravity cell or in the Edison and Gordon cells?

Question 62. Can you renew a dry cell?

Question 63. How is the Edison cell made, and what is its voltage?

Question 64. If it takes 250 milli amperes to work a 300 ohm relay on a telegraph circuit 25 miles long, consisting of a No. 10 N. B. S. galvanized iron wire of the B. B. grade (see table No. 5, June lesson), how many gravity cells must be connected in series to force the 250 milli amperes required to work the relay through both the line resistance and resistance of the relay?

Question 65. How many gravity cells must be used if there are six stations on the line having a 300 ohm relay in each?

Shop Motor Section

Edited by Geo. W. Cravens

D. C. Starting Rheostats and Controllers.

There was a time when rheostats of all kinds were looked upon as "necessary evils", and they are still necessary, but not **evil.** In fact they are one of the most valuable adjuncts of any electrical installation, and if most any of the standard makes are chosen they will give practically no trouble. Most every electrical man knows something about them but we will discuss them for the benefit of the large number of ambitious fellows who want to know more about them.

Strictly speaking, a rheostat is an "adjustable resistance" and the name should apply only to the resistance material behind the face plate of the containing box. But custom makes the term include the resistance adjusting switch as well as the resistance itself, when the switch is of the dial type, although the switch and resistance are usually referred to separately if the switch is of the drum type. A "controller" is a drum type switch, and the resistance is usually entirely separate from the case containing the drum. So we will make these distinctions here when discussing them.

Rheostats are of several kinds, their design and construction depending upon their uses, and their names indicating such use in most cases. For instance, we hear of starting rheostats, speed regulators, self-starters, etc., and the name tells us in a general way what the rheostat does. Controllers also are known by their function and we call them machine tool controllers, crane and hoist controllers, etc., according to their uses. In addition to these there are several special types, but we will not deal with them here. Nearly every line of motor driven machinery has at least one special style of controller or rheostat suited to that service only, and we cannot include them all here.

The most common and best known form of rheostat is the "starting box" or motor starting rheostat. They are designed to start an electric motor and bring it gradually from rest to full speed, but must never be used to regulate or vary the speed of the motor. If caution is not used in this matter the resistance is likely to be burned out because it is designed to carry the current for a short time only.

In order that all users of rheostats may know what to expect of them and that all makers will be on an equal basis, the American Institute of Electrical Engineers has adopted as a standard that motors are assumed to start in 15 seconds, under ordinary operating conditions, taking not more than 150% of the rated current to start the motor, and that the starter should have sufficient capacity under these conditions to start the motor once every four minutes for one hour.

Starting rheostats are made for mounting on the wall or on the floor, the smaller ones usually being for wall mounting. These consist of ventilated steel or iron boxes containing the resistances with slate panel face plates carrying the switch parts, contacts, terminals, etc. When the rheostat is too large for mounting on the wall or switchboard panel it is made with the resistances in a frame of steel angles or other suitable material, with the face plate on the top or one side, and they are called "floor type." Sometimes the face plate is on the switchboard with leads running to the box containing the resistances, but this is usually pretty expensive.

When the rheostat switch is of the "dial type," having the successive sections of resistance cut out by moving a pivoted lever over contact buttons of segments, it is known as a "sliding contact" starter. This type is used for motors of 35 horse power and less, but for motors of more than 35 horse power at 115 volts or 50 horse power at 230 and 500 volts a multiple switch or a drum type should be used. Multiple switch starters have a separate switch for cutting out each section of the resistance, thus eliminating arcing and burning at the contacts. They are usually provided with renewable copper or carbon contacts and operate with a quick-break or snapping action. The face plate carrying the switches is usually mounted on the front of the box containing the resistance, as with sliding contact starters.

Motor starting rheostats are most always used simply for starting the motor in one direction of rotation, although starters are sometimes made to start the motor in either direction and are then known as reversible motor starters. When they are made to both start a motor and to regulate its speed they are called "compound starters" and the resistance used is a combination of heavy armature resistance for starting duty and a lighter shunt field resistance for speed regulation.

All starting rheostats should be provided with no-voltage release coils and magnets to allow the starting lever to fly back to the starting position in case the line voltage should fail. This release magnet also acts as a holding magnet while the motor is running, holding the contact arm in full running position. If this magnet failed to release the arm the motor would be damaged in case the full line potential should be put across the motor with the armature standing still, because the resistance of the armature coils is quite low and there would be no counter electro-motive force to cut down the amount of current flowing.

It is sometimes advisable to provide starters with both overload and no-voltage release coils, the overload coils being so arranged as to cut the no-voltage coil out of circuit in case a load of more than the desired amount is put upon the motor, thus allowing the lever to fly back to the off position and shutting down the motor, or opening the main circuit for the same purpose.

Motor speed regulators are similar in appearance to starters, but the resistance is of sufficient capacity to carry the full load current of the motor continuously on any step. This is especially important in regulating rheostats for machine tools, as they frequently operate for several hours without

stopping. If the motor drives a fan or a pump it may be compelled to run night and day for long periods without stopping, so the resistance in the regulator must be heavy enough to stand this service.

Before going further with the regulators let us consider the kinds of motors a little and see what the different motors demand of their regulators. The three principal kinds of direct current motors are the series, shunt and compound, the name indicating the method of connection and style of windings. Series motors are used almost exclusively for hoists, cranes, elevators and railway work and generally are equipped with drum controllers and separate resistances. For practically all other purposes the shunt and compound wound motors are used, and it is for these that regulators are most used.

The speed of shunt and compound wound motors may be varied in two ways—by inserting resistance in series with the armature and reducing the speed, or in series with field coils and increasing the speed. So, by combining these two methods we can get a wide range of speed variation. When armature resistance is used, the speed will depend partly upon the amount of resistance and partly upon the load, but with field resistance only the speed will depend entirely upon the amount of resistance and not at all upon the load. There are a great many factors which enter into the speed control of motors, especially direct current motors, and these will be taken up in a later Motor Talk as they are warth discussing in detail.

Machine tool motor speed regulators are usually called "controllers" because they are used for the same class of service as the drum type controllers, but they look very much like any other regulator with its starting lever extended to form a handle for moving. All kinds of regulators have no-voltage release magnets on them, these being arranged to hold the arm in any position and releasing it on failure of voltage. They are made to vary the speed of motors either by resistance in series with the armature or by resistance in both field and armature circuits.

Drum type motor controllers, or "drum controllers" as they are usually called, consist of a cast iron or cast steel frame and a sheet steel cover for containing the operating parts, together with these parts. The mechanism consists of two or more elements inside the case and the resistance in another case, a handle being provided for operating, and the necessary connections between the resistance and the switching mechanism.

The parts inside the controller frame consist of a rotating cylinder carrying contact segments and a block of insulating material carrying contact fingers to which the wires from the resistance come. When both armature and shunt field regulation are necessary there is another set of contact fingers provided and extra contact segments are added to the cylinder. This type of controller has many advantages over the dial type and no-voltage and over-load coils may be used in connection with them if desired.

Among the principal advantages are the fact that they are entirely enclosed, may be made water-proof, live parts are covered, operating parts are protected from injury, dust, etc., and the contacts are wiped clean by the action of the fingers. Magnetic blow-outs are provided and the position of the contact cylinder is positively fixed by a notched wheel, so there is very little opportunity for the user to injure them.

The elements used for the resistances vary in size and capacity with the service for which the rheostat is designed, and are made so that any desired combination may be made. They are usually made of wire wound on asbestos tubes for small starting rheostats, these tubes being supported in a box or frame, and of cast iron grids for large rheostats. The resistance wire is of tinned iron, German silver, or other high resistance metal such as some of the patented alloys, and usually is not effected by moisture. In some cases the units are coated with cement or some sort of enamel and baked.

When starting a motor the resistance is all in circuit and is cut out gradually as the motor comes up to speed. If the speed is controlled by both armature and field resistance, the armature resistance is first cut out and then resistance cut into the field circuit, thus increasing the speed gradually over a wide range. The customary amount of resistance for field rheostats is sufficient to give a speed range of 5 to 1 and for armature control to give 2 to 1, although 6 to 1 for field control is frequently used, thus giving an entire speed variation of 7 or 8 to 1 by both methods.

The methods of connecting the rheostats in circuit have already been shown in previous Motor Talks, and these should be referred to in connection with this article to get a full understanding. Makers catalogues also contain a large amount of valuable information and may usually be had for the asking. Our next Motor Talk will deal with A.C. rheostats and controllers.

LINE SHAFT BEARING TESTS.

At the recent New York meeting of the American Society of Mechanical Engineers December 2nd to 5th, inclusive, 1913, a very interesting paper—Comparative Tests of Three Types of Lineshaft Bearings, by Carl C. Thomas, E. R. Maurer, and L. E. A. Kelso, —was read by Professor Carl C. Thomas, now Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md., formerly Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis.

The paper reports experimental determinations of the absolute and relative amounts of power required to drive a specially constructed series of shafts, flexibly connected and carrying known loads uniformly distributed over successively, 20 ring-oiled babbitt bearings manufactured by The Dodge Manufacturing Company, 20 roller bearings manufactured by the Hyatt Roller Bearing Company, and 20 ball bearings manufactured by The Hess-Bright Manufacturing Company. A great range of loads and speeds was covered, and coefficients of friction were worked out for each type of bearing.

The apparatus was designed and built in the Department of Steam and Gas Engineering at the University of Wisconsin, and in collaboration with the manufacturers of the bearings, and was so arranged that very exact measurements of power were attainable. All questions of possible lack of alignment, nonuniformity of loading, temperature and quality of lubricant, etc., were given careful study, resulting in the special form of apparatus used. The tests extended over a period of four years, were finally repeated and all results checked by a set of skilled observers, who had formerly had no connection with the work, and hence their authenticity can be vouched for.

The following data regarding coefficients of friction for the three types of bearings at various loads and temperatures of bearing, and at a peripheral speed of

the shaft of 150 ft. per minute, corresponding to average lineshaft speed of 235 RPM are interesting:

COMPARISON OF COEFFICIENTS OF FRICTION.

Peripheral speed of shaft = 150 ft. per min. corresponding to 235 R. P. M.

Bearing	Average load per bearing=727 lbs. Temp. bearing=77° F. Coeff. Friction	Temp. bearing=100° F. Coeff. Friction	Average load per bearing=1227 lbs. Temp. bearing=77° F. Coeff. Friction	Temp. bearing=100° F. Coeff. Friction	Average load per bearing=1727 lbs. Temp. bearing=77° F. Coeff. Friction	Temp. bearing=100° F. Coeff. Friction
Ball	0.0025	0.0019	0.0022	0.0018	0.0020	0.0016
Roller	0.0069	0.0055	0.0055	0.0047	0.0049	0.0042
Babbitt	0.0112	0.0075	0.0082	0.0058	0.0070	0.0051

Another interesting table presenting the comparison in a different way is given below. This table gives the relative amounts of power consumed in friction by the three types of bearings assuming the relative amount of power consumed in friction by the ball bearing as 1. The relative numbers given are based in each case on the average power for three loads: 710, 1210, and 1710 lbs. for ball bearing; 740, 1240, and 1740 lbs. for roller bearing; 730, 1230, and 1730 lbs. for babbitt bearing.

COMPARISON OF RELATIVE AMOUNTS OF POWER CONSUMED IN FRICTION.

Bearing	Peripheral speed=100 ft. per min. corresponding to 157 R.P.M. Temperature of bearing=77° F.	Temperature of bearing=100° F.	Peripheral speed=300 ft. per min. corresponding to 470 R.P.M. Temperature of bearing=77° F.	Temperature of bearing=100° F.
Ball	1	1	1	1
Roller	2.2	2.5	2.7	3
Babbitt	3	3.6	4.5	4

In addition to the above, which will give an idea of the scope of the paper, there is various other valuable information, and all users of lineshaft hangers, as well as others interested in this subject, will find it well worth their while to procure a copy of this interesting paper and give it their careful reading.

A. B. C. Car Lighting Course

Edited by Edward Wray

LESSON NO. 24.

DICK (European) SYSTEM.

This system of car lighting was designed by Mr. Emil Dick, Chief Engineer of the Austrian Siemens-Schuckert Works. It is used most extensively in the Austrian Railways and on the Oriental Railroad of Turkey, and also to a certain extent by other continental roads. This equipment, although apparently inferior to most of the American systems, contains many points which will interest our readers.

Generator.

The generator is a four pole machine and the armature coils of the drum winding are embedded in armature slots. Four carbon brushes are supplied and are placed 90° apart. As explained in previous lessons of this course, the current from a four pole generator may be taken from any two adjacent brushes 90° apart, the other two being omitted if it is so desired. Where all four brushes are employed, however, it eliminates the danger of failure through brush trouble, for although one brush might stick or get out of order, it is very unlikely that both brushes of the same polarity would be in trouble at the same time.

Pole Changer.

The brush rig is arranged so that it can revolve through an angle of 90°, so that when the direction of motion reverses, the friction of the commutator on the brushes will shift the brush rig through this 90° angle, thereby bringing the positive brush into what was formerly the position of the negative brush.

This insures constant polarity to the external circuit when the polarity of the armature is reversed due to the reversal in direction of rotation.

Automatic Switch.

The automatic switch as shown in the accompanying diagram, consists of a compound solenoid having both the shunt and series winding, very similar in construction to the automatic switches used in this country.

As the train gets up to cutting in speed of approximately 15 miles per hour, the shunt winding is then sufficiently energized to pull down the soft iron plunger, thereby closing the switch contact at the bottom, This connects the generator to battery and lamps, and at the same time lifts the lamp regulator contact, to which is connected through a pivoted bar, shown at the upper right hand corner of the diagram, Fig. No. 334.

These switch contacts are all made in mercury cups and in this respect this equipment is different from any American car lighting equipment. The contacts in the generator regulator are also made by mercury as explained later. Mercury has the peculiar property of amalgamating with certain metals such as copper, zinc, etc., that is, it wets the surface of the metal just as water wets a piece of wood; so that when the copper or zinc switch contact is inserted in the small mercury cup, the mercury, being a metal, makes an excellent contact for the electric current.

When the speed of the train decreases and the generator voltage falls below that of the battery, a reverse current will flow from the battery to the generator through the series winding of the automatic switch, and the magnetism of this reverse current through the series coil will neutralize the magnetism of the shunt coil and cause the switch to open. The right hand rod being somewhat heavier than the left hand rod carrying the auto switch plunger (to which it is connected by means of the pivoted bar) drops as soon as the magnetism of the auto switch is neutralized; in doing so it short circuits the lamp regulator resistance.

Generator Regulator.

This regulator is a combination current voltage regulator, that is, it regulates both the generator current and voltage; it is, however, different in principle from the modern American voltage current regulators, as will be described later. This regulator controls the generator output by varying the generator field current by means of an adjustable resistance. An interesting feature about this regulator is that the contact to the various segments of generator field resistance is made by means of mercury. The contact chamber is made up of a number of metal rings having insulating rings between, these are laid alternately, one above the other, the whole pile being securely bolted together. This chamber is then part-

ly filled with mercury and the plunger of the regulating solenoid extends into this as a loose fitting piston.

When the automatic switch first closes, there is not sufficient magnetism in either the shunt or series coils of the regulator to lift the plunger so it rests on the bottom of the mercury chamber, this forces the mercury upward around the piston and makes contact with all the metal rings connected to the segments of the generator field resistance. As the train speeds up, the generator current and voltage both rise causing the magnetism of the shunt and series coils to increase and lift the plunger. This draws the piston

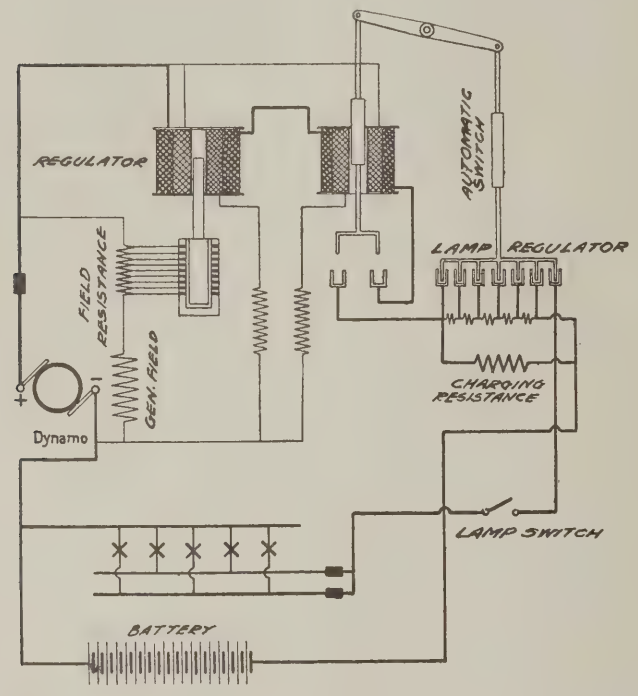

Fig. 133—Wiring Diagram of Dick System with Single Battery.

out of the mercury chamber a little and allows the mercury level in the chamber to fall, considerably; this breaks the connection to the top contact ring. As the speed rises still higher, the plunger will be drawn further into the solenoid, breaking contact successively with the second, third, fourth, etc., rings. As contact is broken with these rings by the fall of mercury in the chamber, this cuts in segments of the generator field resistance, which reduces the generator field current to compensate for rise in train speed.

Although this equipment controls both the generator voltage and current to normal limits it is very different in principle to the operation of the modern "voltage-current" car lighting regulators in this country, such as the Gould Simplex, the Safety Type F, the U. S. L. Types S-2, A-1, etc. In this equipment both the series current solenoid and the shunt voltage coil are wound on the same core and both are effective in controlling plunger at all times.

The magnetism of the voltage coil opposes the magnetism of the current coil, therefore, because of these opposing forces, the energy used in each of the coils must be fairly large in order that the difference between the two may produce the desired pull on the plunger.

It will be noted from referring to our description in previous lessons of the American regulators of the current voltage type, that until the voltage of the generator rises above a certain point the current coil alone is effective in controlling the operation of the regulator; that is, the equipment operates as a simple constant current regulator until the battery becomes charged. This makes it possible to use a much smaller coil both in the voltage and current regulators, where the magnetism of the two coils is entirely separated, than where they are combined in the same solenoid as in this case. Moreover, the voltage coil can be adjusted so that it will taper the generator current off much more rapidly as the battery becomes charged than where the two coils are combined in the same solenoid.

Diagram Fig. 134, shows wiring diagram of equipment with a double battery. A peculiar switch arrangement will be noted in the right hand lower corner. This is different from any types of American switches, but is very common in European operation. A long bar which may be pulled in or out carries a number of contact faces as shown in Fig. No. 134, so that when in position No. I, it would make contact with the upper four points of the switch, thereby connecting both batteries on charge, the lamps being then disconnected. In position No. II it connects battery No. 1 for charge through the charging resistance and connects the lamp to battery No. II and the generator. Position No. III is the same as position No. I and position No. IV the same as position No. II except that the batteries are interchanged; that is, battery No. 2 is charged by the generator separately, and lamps are fed from battery No. I and the generator. This switch can be set at any one of the four points by the train crew and a lock is provided to which the conductor carries the key so that it can not be shifted except by the proper parties.

Supposing the switch is standing in position No. I or No. III: as soon as the automatic switch operates, it will pull down the left hand rod, closing the circuit between the two mercury cups of the automatic switch; at the same time it will raise the right hand rod, opening the

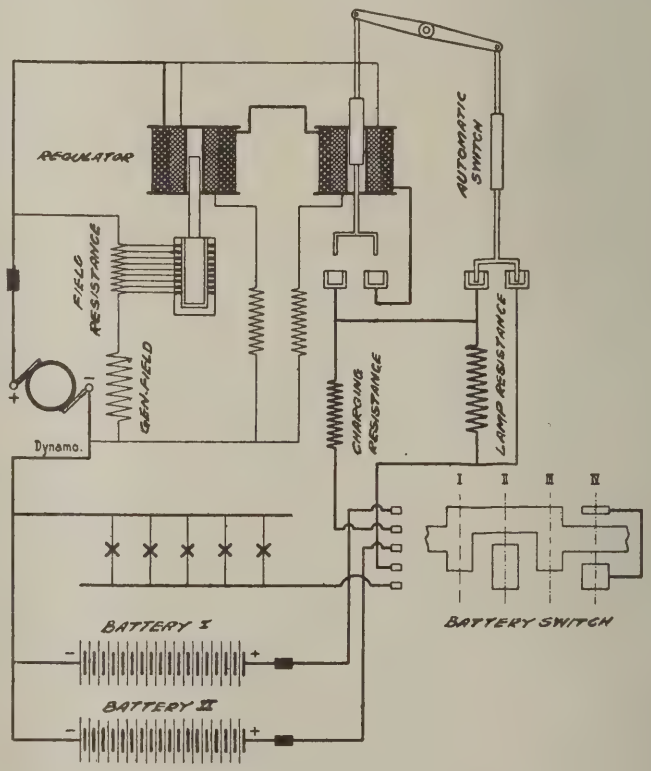

Fig. 134. Wiring Diagram of Dick System with Double Battery.

short circuit across the lamp resistance. The generator current will then flow through the switch contacts, dividing, part going through the lamp resistance and part through the charging resistance, but these currents combine in the battery switch and pass into the two batteries which are connected in parallel.

When the lamps are required, the battery switch is

pulled to either position No. II or No. IV, depending upon which battery has the greater charge. If in the position No. II, battery No. I will be connected directly to the generator, but through the charging resistance, and battery No. 2, will be connected to the lamps and the generator feeds through the lamp resistance.

This lamp resistance is of a higher resistance than the charging resistance so it will cut the voltage delivered

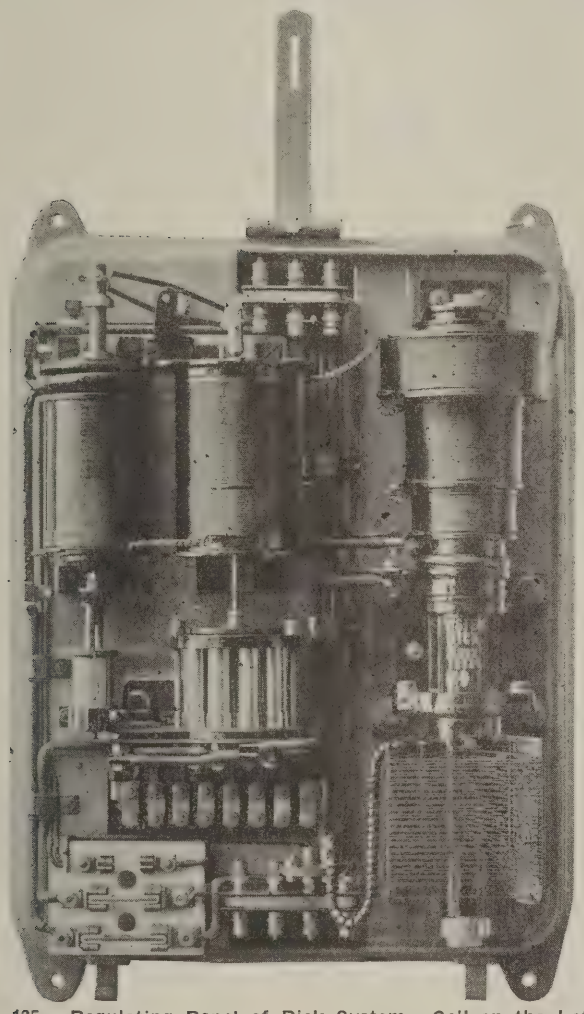

Fig. 135. Regulating Panel of Dick System. Coil on the Left is Automatic Switch; Center Coil Short Circuits Lamp Resistance Segments Through Mercury Cup Tubes; Right Hand Solenoid Is Voltage Current Regulator.

to the lamps and battery No. 2 down below that delivered to battery No. 1. If battery No. 2 is fully charged so that its voltage is equal to, or slightly above, normal lamp voltage, it will furnish a certain amount of current to the lamps, the balance coming from the generator through the lamp resistance.

If battery No. 2 is in a low state of charge when it is connected to the lamps, it will not assume its full share of the lamp load, so more current will be drawn from the generator through the lamp resistance. Increasing this current through the lamp resistance, however, will increase the voltage drop in that resistance and so lower the effective voltage delivered to the lamps and battery No. 2.

It is very obvious that this system is rather crude when compared with the more modern American systems; but inasmuch as there is only one-lamp circuit provided with the double battery equipment, the lamps will be either all on or all off, so the problem is very much simplified.

As explained above, however, the amount of voltage drop in the lamp resistance, which regulates the voltage to lamps, will depend upon the state of charge of battery No. 2 (if the switch is in position No. 2). Moreover, the generator voltage will rise somewhat with the rise in counter electro-motive force of battery No. 1, so that the lamp voltage, which is the generator voltage minus the drop in lamp resistance, may vary over considerably ranges.

In the single battery equipment, as shown on Fig. 134, the lamp resistance is simply divided up into a number of parts and the level of mercury being adjusted to different heights in the various cups, causes the resistance to be short circuited, one segment at a time, as the rake device drops. The rise or fall of lamp voltage, as the switch is closed or opened, is then gradual.

It will be noticed from referring to Fig. 135, that there are two large coils for the automatic switch shown at the upper left hand corner of the board, with pivoted arm above the coil at the right which carries the rake contact for lamp resistance segments with mercury cups below.

The regulator is shown at the right hand side of the bar instead of at the left as in the diagrams. It will be noted that the field resistance is wound in the open on a frame on the fall of the board. It would seem that this construction is rather of too temporary a nature for railroad service, but possibly the conditions under which this equipment operates in Austria and Turkey are somewhat different from those in this country.

The equipment is designed for 24-volt operation and it is stated that the lamps consume about 1.4 watts per candle at 24 volts and at 29 volts, the highest voltage, only 1.0 watt per candle. This indicates a rise of 5 volts, or about 20% above normal . . . from a study of the wiring diagrams, however, this is about what we would expect from this equipment.

We are indebted to Dr. Max Büttner of Berlin, Germany, for the information and photographs contained in this article.

ST. LOUIS CAR LIGHTING CLUB.

At the November meeting of the Club the following officers were elected:

President—H. J. Pfeffer, Missouri Pacific Railroad.
Vice-President—P. B. Streeper, Wabash Railroad.
Secretary—O. E. Hencken, Pullman Company.
Treasurer—G. E. Sampson, M., K. & T. Ry.

The Association has had a very successful year, the meetings being well attended and many practical questions were taken up and discussed at each of the meetings. Some of the questions submitted at the last meeting are as follows:

(1) What will be the effect if a U. S. L. type S-2 potential relay becomes grounded?

(2) Why should a set of batteries get hot when discharged at normal rate?

Mr.W. E. Buckmaster, Traveling Inspector of Car Electric Lighting for the Baltimore & Ohio System, addressed the first meeting in December of the St. Louis Car Lighting Club and made a few remarks covering the development of the axle lighting game. He called attention to the necessity for watching the small things; these, he said, would eliminate most of the larger trouble. The visitor's presence was appreciated, the remarks made were practical, brief and interesting.

Mr. C. A. Luckey, of the Edison Storage Battery Co., addressed the second December meeting on the subject of "The Edison Battery;" he described the various processes of manufacture of this battery and explained its operating characteristics. St. Louis has a live organization in its Car Lighting Club which other large railroad centers would do well to pattern after.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

A Test for North and South Poles in a D. C. Generator.

When replacing a new set of field coils or coils which have been repaired, the coils should always be tested for north and south pole so as to determine if they are properly replaced. These coils are not always tagged and if one coil of a 4-pole generator is reversed, it will make the generator have 3 south poles and 1 north pole, or 3 north poles and 1 south pole, a condition which would greatly unbalance the generator and prevent its working properly.

After the field coils have been replaced and connected up, but before the armature is inserted, pass a mild current through the field coils by connecting to a battery or other d. c. circuit through a resistance if the generator is in the shop, or if the generator is on the car, close the automobile switch with the main fuse in. If a compass is handy, place it near the face of each pole of the generator and the north pole of the compass will be attracted to each south pole of the generator and the south pole of the compass to each north pole of the generator.

If a compass is not on hand, this test can easily be made by tieing a string to the center of a needle; then take your screw driver and rub it across one of the poles so as to magnetize it, and then stroke the needle a few times with the magnetized screw driver so as to magnetize the needle. The thread holding the needle should be 8 or 10 inches long so that the needle is free to turn when hung near the generator fields

If the fields are connected properly it will be found that the needle when suspended near each of the poles successively, will turn its point to two of them and its eye to two of them. If it turns the eye to three of them, and the point to only one, or the point to three and the eye to one, the field coil on the middle pole of the three should be reversed.

G. C. Elbreder.

Commutator Grinding.

Dear Editor and Night School Teacher:

Here is a practical stunt for your paper.

Still being interested in my old associates and their occupations, I am ever on the look-out to make their troubles lighter, if possible.

Heretofore, it has always been a practice to sand paper commutators. Often times this is done on account of high mica. Sand paper, however, has a tendency to increase high mica rather than to reduce it, unless the sand paper is glued to a block before applying, as it will follow over the edges of the high mica and have a tendency to scoop the copper out. Other times, the armatures are removed and the commutator turned to bring down the high mica, etc., sometimes the mica is drawn or filed down between the commutator segments.

A better plan is to use a piece of sandstone instead of sand paper as it will take the mica down evenly with the copper. By the use of sandstone a commutator can be put in condition without removing the armature to be turned if it is not in too bad a condition. An old grind stone can be broken up and pieces of this used for cleaning up bad commutators or reducing high mica.

"Next week I will write about applying an axle device to a hay rack."

F. E. Hutchison.

Testing Axle Generators.

It quite often happens that a doubt will exist in the mind of an inspector as to whether a dynamo will pick up when it goes out on the road, although it might motor all right in the yard. The test that seems to be the best for this purpose is to motor the dynamo in the ordinary way, gradually cutting resistance into the field and allowing the dynamo to speed up. After the dynamo has reached a high speed, if the inspector will pull out the automatic switch and let go of it, at the same time cutting the resistance out of the field, the momentum of the armature will be sufficient to cause the dynamo to generate current enough to pull the automatic switch in for a short time. This test will show that the connections are correct, that the automatic switch is working properly, and that the resistance is working properly. If the automatic switch is set to go in at a very high voltage it will be indicated by the switch not going in, and if for any reason there is a tendency for the switch to stick in, it will show up, as with this test the voltage decreases and the switch drops out as it would in service, and is different from its dropping out from motoring the dynamo. At times the carbon discs in the regulators get in bad order and there is too much resistance in the field circuit, and yet the dynamo will motor all right, but will not pick up. This test will expose that fault.

Topeka, Kans. S. W. Everett.

Type A Consolidated Regulator Stunt.

With the Consolidated type "A" equipment, it is quite often found that the motor ratchet dogs, motor, or some other part of the regulator mechanism becomes defective, and an inspector has not time to repair same. We have found that we could send the car through to a terminal by setting the rheostat arm around to about 5 o'clock and disconnect the motor. This amount of field resistance, by experience, is found to be proper to keep the main generator current from going too high, and also to allow the machine to pick up. A failure of light can thus be avoided.

A. Voigt.

Testing Generator Fields.

I find that open circuits often occur in the fields of axle lighting dynamos. The faulty coil may easily be detected without disconnecting the coils from each other by the following method: Connect the field terminal to the battery terminals, of course no current will flow through the open field but if a voltmeter is connected across each single field coil in succession, it will show no deflection if the coil is continuous because both poles of the meter will be connected to the same side of the battery circuit, but if the coil is open one of the voltmeter terminals will be connected to one side of the battery circuit and the other terminal to the other side

so that the voltmeter will show the full E. M. F. of the battery.

Current may be obtained from the battery to the field by removing the main generator fuse and closing the automatic switch; also a wire jumper may be used in place of the voltmeter, a spark will be obtained when the wire is jumped around the open coil.

F. B. Jones, Topeka.

Battery Connectors.

Every electrician in charge of passenger car lighting equipment knows that the corrosion of connectors and terminal lugs is a serious source of trouble and if allowed to go too far will injure the battery. Lead nuts for connector trays of terminal lugs are practically useless for cars that have to travel very long distances, for the vibration loosens the nuts and inspection points are infrequent. I use the old style brass nuts, ½-in. if available, clean the terminal lugs thoroughly so that they are free from moisture, and tighten the nut solid (not with a hot wrench like some men do). The connector and battery post are then thoroughly painted with a quick drying enamel, the positive post red, and the negative post blue. Care should be taken that the cell is otherwise in good condition so that the enameled connection, once made, need not be broken for a long time. J. G. Coppel.

Temporary Fuse Plugs.

Recently our supply of Edison fuse plugs became entirely exhausted and being greatly in need of some one day we were forced to take advantage of the following stunt, which we think practical and may help out some of the other fellows in similar trouble.

We took the base of a lamp that had been burned out and broke the stem off just above the platinum tips, leaving the carbon leads exposed. We then twisted these leads together and inserted this improvised plug into the receptacle.

These plugs have operated in circuits that have pulled as much as 8 amperes, without over heating.

Of course, this might be considered very bad practice, but in such an emergency it was about the best thing that could be done. Most all axle light men are acquainted with the methods of putting coins into the receptacle, or cutting the outer contact of a bad plug and bending it over to meet the center, which very often results in finding two "doctored" plugs in the same circuit.

But by using the base of an old lamp as described above, this danger is eliminated to a large degree, as a man can see at a glance just how many of these fake plugs he has on the board and they can be arranged so as to have at least one good plug in each circuit. At the first opportunity these temporary plugs can be replaced by new plugs of the proper capacity.—W. J. Davison, and H. W. Eaton, "Frisco Lines."

Prize Question Box

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

Better send in your questions now, while you think of it.

First Prize

Axle Generator Alignment.

In an axle-lighting equipment, why is it that, when a dynamo is out of level compared to the car axle to which the axle-pulley is attached, that, when the car is moving in one direction the belt will run to one side of the dynamo pulley, but, when the car is running in the opposite direction, the belt will run to the other side of the dynamo pulley?

In this connection I would like to have you explain also why it is that, when a pulley is crowned, the belt will stay in the center of the pulley running to the high point, but, when the shaft of the dynamo is not parallel with the car axle, the belt will run to the low side, or the side nearest the car axle.

I am enclosing sketches showing the different conditions.

S. W. Everett.

Ans. As you state, one of the commonest laws of operation of belts is that they run to the high side, so that in a crown pulley, if the belt is off center it will run up on the crown until the center of the belt comes over the center of crown, at which point the tendency of one-half of the belt to run to the high side will be balanced by the tendency of the other half of the belt acting the same way in the opposite direction.

It is a well known fact, however, that in many cases where very wide belts, in proportion to their length, are employed, they do not seem to follow this rule. This

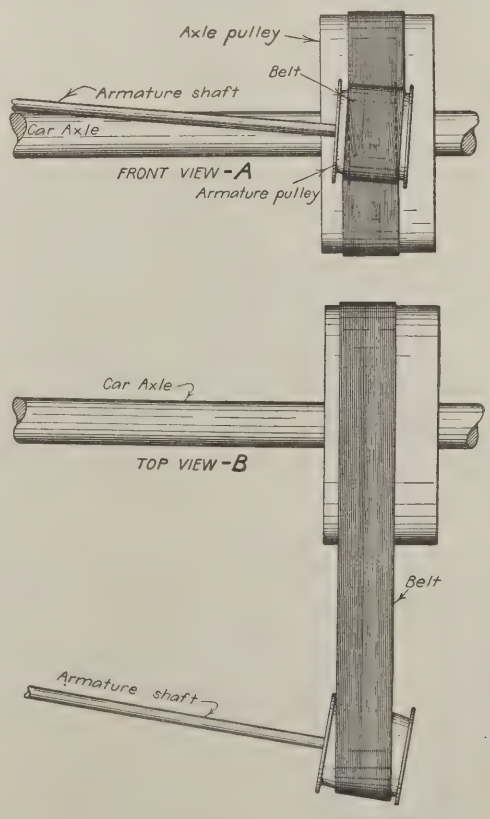

Diagram Showing Front View and Plan View of Axle Belt with Pulleys.

is probably due to diagonal stresses within the belt, which may draw it to one side or the other.

The diagram "A" refers to the first paragraph of your question and shows a front view of the axle pulley and generator pulley, with the generator shaft badly out of level. If the belt is traveling so that it passes downward over the face of the generator pulley it will be carried to the left slightly, as it passes over the generator pulley, because of the fact that the armature shaft is tilted. The amount of this shift over to the left is indicated by the difference between the dotted line and the belt edge as it leaves the pulley.

This will cause the belt to creep to the left until that tendency is overcome by the reverse tendency to ride the crown of the pulley, or until the belt rubs against the flange of the generator pulley.

If the direction of car motion reverses, so that the belt passes upward over the face of the armature pulley, the action will be just the reverse. Any point on the belt as it revolves with the armature pulley will be carried slightly to the right and the tendency will be for the belt to creep to the right until this tendency is overcome by the tendency to ride the pulley crown or until the belt rubs against the flange. If the generator is tilted in the opposite direction of belt shift will, of course, be just the opposite.

Diagram "B" of the accompanying sketch refers to the second paragraph of your question. In both of these diagrams, however, the armature shaft is shown badly out of line so as to explain the action more clearly. According to the way a belt acts on a crown pulley, we would expect this belt to crowd the outer flange of the pulley, which is the high side, or that farthest away from the center of the car axle. We find by practical experience, however, that this belt actually goes to the low side. This is contrary to the usual experience with belts, but is probably due to the fact that the car lighting belt is rather wide and heavy and of comparatively short distances between pulley centers, so that diagonal stresses are set up within the belt which draw it to the low side.

This shows the importance of both leveling and carefully aligning the generator if the belt is found to run to one side. The most common trouble is that the generator gets out of line (its shaft not parallel to the car axle, but both level). Don't wait for the belt to ride the flange . . . if it is off center but even though it does not strike the flange it would be well to pull back on the side crowded, *but only if you are sure the generator is level.*

Second Prize

Care of Ball Bearings.

Ques. With the widespread application of ball bearings to railway car-lighting generators during the past year some questions as to their care have arisen, which I would like to have answered in the "Question Box."

How much grease should be put into a ball bearing at one application? How long ought a bearing to run without further attention after it has been so greased?

G. R. F., Buffalo.

Ans. When ball bearings were first applied, the instructions were to inject a small amount of grease into the bearing, by means of a grease gun, once a month. Experience developed the fact that in most cases too much grease was injected with the result that some grease leaked out of the bearing into the generator proper, covering commutator, armature and field coils with grease.

The period for injecting grease has been gradually extended. A series of tests was made by one of the large roads of the East, in which three car lighting generators had their bearings filled about two-thirds full of grease, and were then carefully sealed and run for six months without any attention whatever to the bearings. At the end of this six months' test all six bearings of the three generators were found to be in perfect condition and the condition of the grease in the bearings indicated that the test could have been two or three months longer without injury to bearings.

As a result of these tests a six months' period for greasing the bearings has been decided upon and the grease gun nipples originally applied to all generators have been removed. The bearings are removed once in six months and thoroughly cleaned in gasoline so as to remove all the old grease with its collection of grit. The bearing should be then filled about two-thirds full of the best grease obtainable.

Third Prize

Field Troubles.

Ques. What makes the fields burn up on the U. S. L. equipment with three leads coming out of the machine, when the negative lead breaks outside of the machine?

Walter Brightman, Jersey City.

Ans. Connection between field and negative generator is made inside the machine so that when the negative lead breaks, it opens the load circuit of the generator to lamps and battery but does not open the field circuit.

Since no current can flow from the generator to the battery or lamps then there will be no current flowing through the current coil of the regulator. With the more recent types of U. S. L. regulators having voltage control, it might seem that the generator voltage would be controlled to normal value by the voltage coil even though the current coil did not operate. With the negative lead broken, however, the entire regulator board, with the exception of the field circuit, is dead, so there will be no regulation. The generator voltage, meanwhile, will rise higher and higher as the speed increases, since the current can flow unrestricted through the fields, for the connection to negative generator is made within the generator and the field resistance is all cut out. Under severe conditions the generator voltage may rise to almost twice normal value; this would cause the field current to be doubled.

Since the heating effect in any coil of wire varies as the square of the current, doubling the field current will increase the heating in the field coil four times, or even a 40% rise in field current will cause double the heating effect in the generator fields, so it is not surprising that under such conditions the field coils are burned up.

Setting Stop Charge Relay

Ques. I would like to get information in regard to setting stop charge relay on the safety type "D" panel. This relay is supposed to cut in at 40 volts, but I have run one of them up as high as 55 volts with 80 amperes flowing without working the relay. The automatic switch worked properly.

Hugh Hobson, Ludlow, Ky.

Ans. Proper way to adjust a stop charge relay is to connect a few dry cells in series with the car lighting battery so as to boost the voltage of the battery up to 40 volts. The negative of a dry cell should be connected to battery positive and then other dry cells connected, positive to negative, etc., until a total voltage of something over 40 volts is obtained; then by inserting a resistance unit, such as a field rheostat, the voltage across the coil, can be carefully adjusted to 40 volts. The adjusting screws of the relay should then be tightened or loosened, as the case may be, so that the relay will just close at this voltage but will not close if the voltage is below 40 volts.

General News Section

MR. F. R. FROST.

It is with great regret that we must announce the death of Mr. F. R. Frost, formerly electrical engineer of the Santa Fe, who died at the Las Vegas Hospital of the Santa Fe Railway, December 29th. Mr. Frost was most highly esteemed by all who came to know him through business associations or through the activities of the Association of Railway Electrical Engineers.

F. R. Frost.

Mr. Frost was born at Ithaca, New York, in 1870 and was graduated from Cornell University with the degree of Mechanical Engineer in 1893. He later made a special study of alternating current phenomena at the Cornell University, which he supplemented with the student course at the Works of the Westinghouse Mfg. Co. Here he was soon promoted to foreman of the testing department, which position he held for four years. He then became traveling and erecting engineer for the same company and continued in that capacity for two years.

In 1901, the Santa Fe, who had been the first railroad to adopt axle lighting to any extent, and at that time had a large number of equipments in service, appointed Mr. Frost as Electrical Engineer of the System.

Mr. Frost was one of the organizers of the Association of Car Lighting Engineers, the name of which was subsequently changed to the Association of Railway Electrical Engineers, and in 1911 Mr. Frost was elected President of the Association.

We are sure that we voice the sentiment of all the many friends of Mr. Frost in extending our most sincere sympathy and condolences to his wife and family in their great bereavement.

A. J. COLLETT GOES TO SAN DOMINGO

It has just been announced that Mr. A. J. Collett, electrical engineer of the Union Pacific Railway, has been appointed director general of public improvements of San Domingo.

Mr. Collett is a member of the executive committee of the Association of Railway Electrical Engineers and has been in the employ of the Union Pacific Railroad since 1900, being appointed to the position of electrical engineer in 1906. Mr. Collett has always been active in association affairs and was one of the charter members of the Association of Car Lighting Engineers.

STANDARD UNDERGROUND CABLE CO. NOTES.

The Standard Underground Sales Company announce some important changes in their Chicago and St. Louis office territories, consequent upon the death last fall of Mr. J. R. Wiley, who for nearly twenty years was their Western Manager with headquarters at Chicago.

Mr. E. J. Pietzcker, formerly Southwestern Sales Manager, is made Western and Southwestern Sales Manager in charge of the Chicago and St. Louis offices of the company. Mr. Pietzcker has been connected with various branches of the wire and cable

E. G. Pietzker.

industry substantially throughout his entire business experience and is especially qualified to serve the customers of a company which devotes its entire energies to the field of electrical wires and cables and their accessories.

NEW CONSOLIDATED SUSPENSION.

The Consolidated Railway Electric Lighting and Equipment Company has recently been installing a new form of suspension for axle light equipments, which will be of interest to all car lighting men.

The suspension is of the two point swinging type,

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You can cover your entire requisition for all electrical equip-
in one shipment! Think of the convenience! Our Silver
mense stock as well as that in the Chicago warehouses of the

The Alexalite insures **safety, comfort** and **economy** in passenger service.

All light points concealed from range of vision and illumination approximates daylight.

Coil Burnouts are Frequent
in electric headlight and railway car lighting generators where cotton insulation is used—such burnouts are impossible when wound with Deltabeston wire and tape. Only the highest grade annealed copper wire is used; this is overlaid with purified **asbestos fibre,** thoroughly impregnated with special compound and carefully finished, giving a wire of **uniform diameter.** This insulation will stand 500 degrees Fahrenheit without injury.

Deltabeston
is an insurance policy—it will keep your headlights working and prevent car lighting generator burnouts.

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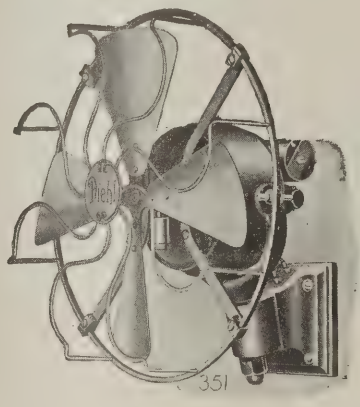
ment on a certain job with one order and receive all goods
Anniversary Catalogue, No. 28, is the key to our own im-
firms we represent. ***Let the "House of Service" serve you.***

OKONITE

TRADE MARK.

The Highest Grade of Insulation Obtainable

should always be used in railway signal and car lighting installations—this is just another way of specifying Okonite. Okonite insulation is tough and very elastic and of high electrical resistance; it is always placed concentrically around the conductor—the result is a product absolutely dependable. Okonite is made in **one** grade only—**THE BEST.**



Diehl Car Fans give a finishing touch to passenger comfort. Designed specially to meet the severe conditions of this service. The fan body is readily removed from the base without disturbing the wiring. Pleasing in design.

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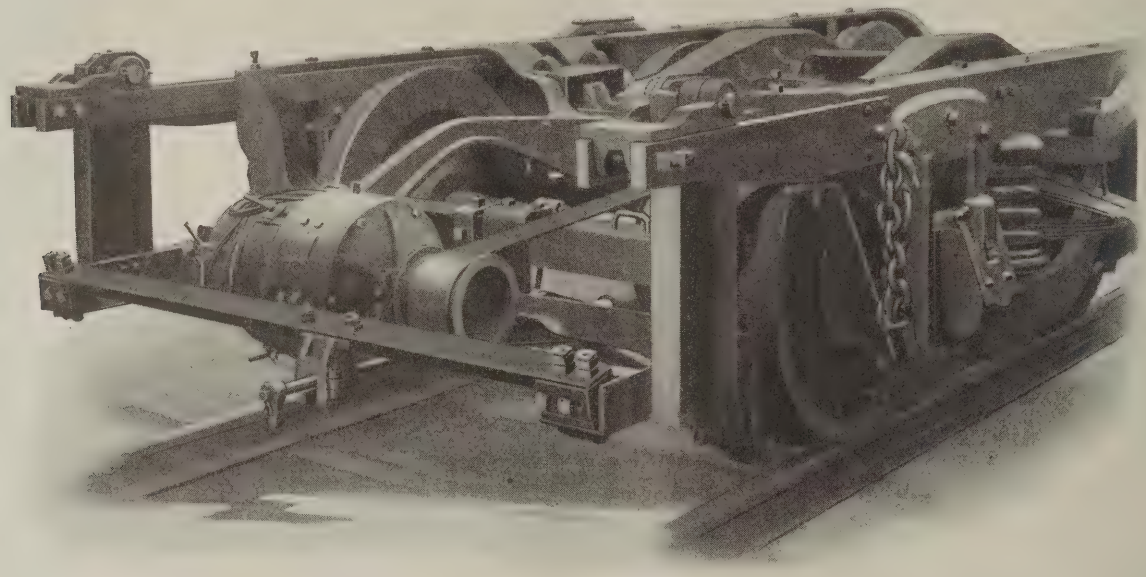
EVEREADY

it being recognized that the necessity of a parallel motion to avoid slopping of oil from the dynamo is no longer necessary on account of the adoption of grease packed bearings. It consists essentially of the ordinary forgings extended from the truck end and braced. From these forgings are suspended vertical members, which in turn support the cradle in which the dynamo rests.

By reference to the illustration, it will be noted that the entire suspension is made of standard structural shapes, it will also be seen that the suspension provides for the maximum clearance above the dynamo and below it. The track clearances are well within the Master Car Builders' rules, as well as the clearances above the dynamo, at the same time, the dynamo is accessible for inspection. The swinging bearings, which are provided with liberal grease wells, in-



New Consolidated Suspension.

to which grease is forced with a gun, are carried in two adjustable saddles for properly aligning the generator with the car axle. They are the only points of wear in the suspension, thus reducing the wearing parts to a minimum. It will be noted that the construction of these bearings is such that the supporting pins are brought into double shear instead of single shear, as is the case with the older link type.

A novel feature of this suspension is the tension device employed, there being an abutment for the spring riveted to the end sill of the truck, against which the tension spring bears. The usual handle nut projects out beyond the suspension for the convenience of the inspector. The advantages of placing the tension rod as near in line with the pull of the belt of an axle driven dynamo, are self-evident and need no comment. The suspension possesses the further advantage in that the tension spring may be dispensed with if desired, and the suspension locked in place, thereby forming a rigid suspension if it is found advantageous to use the rigid type.

Where this suspension is supplied with built up steel trucks instead of the cast steel truck, shown in the illustration, the suspension is made an integral part of the truck itself by simply extending the side channels of the truck out a sufficient distance to carry the saddles and suspension properly.

The dynamo shown in the illustration is the Consolidated Company's Type "D" Ball Bearing Geneing and special glass units for platform and station lighting.

rator, equipped with cast iron hand hold covers instead of the older form with sheet iron covers.

HOLOPHANE REFLECTORS FOR RAILWAY CAR LIGHTING

This is the title of an instructive and interesting bulletin recently issued by the Holophane Works of the General Electric Company, which will be of special interest to all men in charge of electrical work on railroads.

The Holophane Works have made a very careful and accurate study of the requirements of railway lighting and have worked directly with the railway engineers in designing special reflectors for each particular service. It is not necessary to mention the time and expense involved in such work. Until very recently no special attention has been given to proper reflectors for platform lighting and other outdoor service. In railroad service, in addition to correct light distribution, a reflector is required to be of rugged construction to stand rough usage and must not be affected by corrosion from the acid fumes in the soft coal smoke. This need has been met by the development of special heavy duty reflectors heavily enameled throughout. The bottom edge is heavily beaded with the bead turned inside so as to shed water prop-

New Holophane Outdoor Type Reflector.

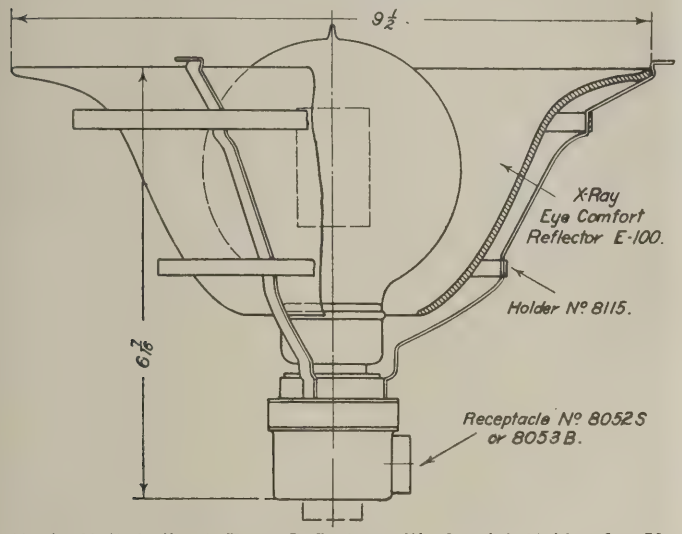
erly and at the same time give an added strength to the reflector.

The bulletin contains a description of other types of lighting units specially designed for day coach, sleeping car, parlor car, and dining car lighting, as well as the aluminumized metal reflector for postal car light-

INDIRECT LIGHTING EQUIPMENT FOR RAILROAD SERVICE.

To meet the growing demand for indirect lighting in railroad service, the Eye Comfort Lighting equipment has been developed and extended so as to include this field.

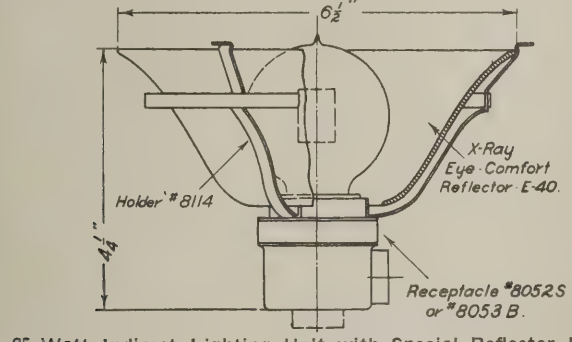
Two types of units thus far have been developed. Fig. 1 shows a single unit equipment. It is used with



Single Unit Indirect Type Reflector with Special Holder for 50-Watt Lamp.

the 50 watt 32 volt train lighting lamp. Fig. 2 shows type of unit,which is used chiefly with the 25 watt train lighting lamp. Several of the latter units are usually placed in one fixture.

The socket shown in these figures, is a special porcelain socket, designed to be used with the special re-



25-Watt Indirect Lighting Unit with Special Reflector Holder.

flector holder. The combination of socket and reflector holder always maintains the proper relation between lamp and reflector.

TABLE I.

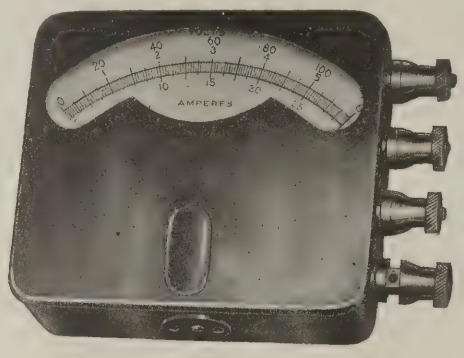
Reflector	Reflector Holder	Receptacle	Volts	Lamp Watts	Bulb
E- 40	8114	8052-S	50-65	10, 15	
		8053-B	25-34	20, 25	G-18½-B
E-100	8115	8052-S	50-65	50	
		8053-B	25-34		G-30 -C

LONG SCALE POCKET METER.

A pocket meter has recently been placed upon the market which has an extra long scale of 120 divisions. This instrument is manufactured by Mr. Lewis M. Pignolet, 78 Cortlandt street, New York; it is of a convenient pocket size, being but 3¼ inches wide, 4½ inches long, and 1¼ inches deep. The scale is 3¼ inches long and permits of very accurate reading. The case is of heavily nickeled brass and carries insulated binding posts on the edge, as shown.

The meter is of the direct current moving coil permanent magnet type, and the moving element is made of very light weight so as to reduce to a minimum the wear and friction upon the jewel supports. The pivots are very carefully polished and are ground to a small radius on the tip, so that ordinary shocks will not cause injury to the jewels or pivots themselves. Highly polished sapphire jewels are used.

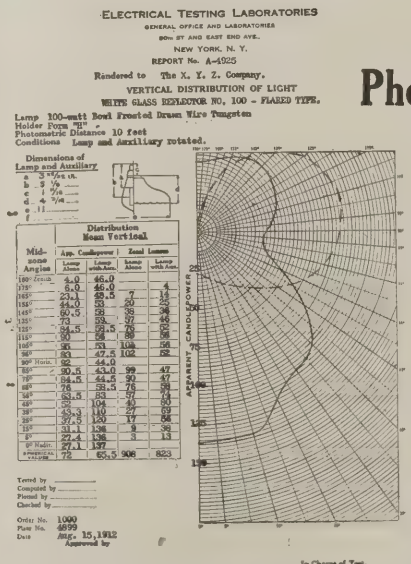
The meter is made in various styles and capacities; a simple volt meter or simple ammeter, double reading



New Pocket Volt Ammeter.

volt meters or ammeters, and two or three reading volt ammeters. The capacities range from 0-1 to 0-120 volts and from 0-1 to 0-50 amperes. A convenient meter for car lighting work and signal work is of a 3 reading volt ammeter type, having a capacity 0 to 3, and 0 to 60 volts, and 0 to 30 amperes. Meters of other styles and capacities are made.

A hand-sewn leather case is provided for the meter. As the meter is of a size that will fit the pocket nicely it is very convenient for use of railroad electricians, signal maintainers, and those having charge of storage batteries.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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Control of Battery Charge in Car Lighting Service.

One of the most important items in the cost of operating axle lighting equipment is the depreciation of the storage battery. This item is one of the most important, not only because it forms a major part of this total cost, but also because it may vary within wide limits, represented by a variation in depreciation of from 15 to over 100 per cent per year, depending upon the care which the storage battery receives.

There is probably no service in which storage batteries are operated where the conditions of operation are more uncertain and more difficult of proper control. The equipment must often go for days without any attention whatever and even on cars which receive daily attention the charging is all done en route, and the discharge which the battery receives may vary greatly, depending upon delays, time of year, etc. The magnitude of this latter variation is shown to be surprisingly great in the curves on page 329 of this issue.

Much ingenuity and perseverance have been displayed by the manufacturers and railroad operating officials as well in the development of axle car lighting systems, and all credit is due them. In its present state an axle device is virtually a little central station that runs itself, and does so under the worst possible conditions of operation. The speed of motor power varies anywhere from 0 to 100 miles per hour, and the generator is mounted directly upon the car truck, where it is subjected to the severe vibration and lash of the truck traveling at high speed, and is driven by an unprotected belt from the car axle, where water, snow and ice, flying sand, cinders and ballast, all militate against the successful operation of the equipment.

It is probably because of the mechanical difficulties involved that more attention has been given to the successful operation of the equipment itself and too little attention given to the operation of the equipment from the storage battery point of view.

Instead of being considered simply as a reservoir of unlimited capacity for absorbing and making up for the shortcomings of the generating and controlling apparatus, the storage battery should be considered as the most important element of the equipment, and the generating and regulating apparatus merely as an auxiliary to properly charge the battery.

Many devices have been employed during the past few years for automatically controlling the amount of charge given the storage battery. The designers, however, have apparently underestimated one of the most fundamental considerations in all storage battery operation, which is that the voltage of a storage battery is no definite indication of its condition of charge. Invariably these devices have depended on the assumption that the battery voltage at the end of charge is a definite value. In practice, however, we find that this voltage at the end of charge may vary anywhere from 36 to 43 volts, at the battery, on a 30-volt system, depending upon the rate of charge, temperature, condition of plates, strength of electrolyte, etc.

So it is not surprising that, after implicit confidence has been placed in these devices by the operators and the charging rate set to the top notch, that a vast number of storage batteries have been ruined by excessive overcharging, and by undercharging with consequent sulphation of the plates as well.

The current voltage principle of regulation, which has been in vogue for the past two years, is an improvement over the stop charge principle of control, inasmuch as the charge is tapered after a certain voltage has been reached, this voltage being somewhat below the final charging voltage at the normal rate. Tests on this type of regulation, however, show that with a variation of from 39 to 42 volts in the setting of the regulator, the final current rate to which the battery charge tapers will increase from 5 amperes to over 50. Since the ordinary variation in battery voltage, as mentioned above, may exceed these limits, to say nothing of the errors in adjustment of the device, it is self-evident that, although a great improvement over the stop charge principle of control, the current voltage principle is yet far from perfect.

Within the past few months a number of ampere hour meters, specially designed for controlling axle equipments, have been placed in service. The operation of ampere hour meters in central station service, covering a period of several years, has developed the fact that the ampere hour meter offers a means of ascertaining and controlling the charge of a storage battery, which is fully as reliable, if not more so, than the specific gravity method which for years has been standard.

It will be interesting indeed to note the success with which this method of control meets the conditions of axle lighting service.

Electric Locomotive Design

The subject of electric locomotive design is one in which every railroad motive power official of the present day is vitally interested, particularly if he has a present or proposed electrified zone to care for. The accompanying illustrations and data, which were presented before the British Institution of Electrical Engineers by F. Lydall recently, contain much information of a valuable and interesting nature, in that the various types of electric locomotives are shown and detailed data given in regard to each. The various types presented do not by any means include all of the types of electric locomotives now in service, but rather indicate an example of each different class of locomotive.

Although the tabular data presented contains a certain amount of detailed information, some of the items require classification and explanation before any direct comparison of types should be made. Moreover in deciding upon the design of the locomotive there are many important details which must be taken into consideration. The service in which that locomotive is to be used is of the first consideration, whether it be switching, freight, suburban, or high speed passenger. This will then determine the maximum speed and tractive effort, as well as other features which vitally affect the design of any locomotive. The design must be such as will offer the greatest reliability in service and low maintenance cost and in considering the later point, all parts to be renewed and requiring special maintenance attention be easily accessible, easily dismantled, and reinstalled, and must be as few and inexpensive as possible. The locomotive in service must cause the least possible damage to the track both as to wear of rails and tendency toward nosing, and its total and distributed weight must be within the limits of the strength of rails and bridges. It is highly desirable that the motors should be able to exert without injury a torque sufficient to skid the driving wheels under any condition of track. A good lookout must be provided for the engineer, principally, of course, in front, but on the sides as well, in switching locomotives.

Precise information as to the actual maintenance costs are not very easy to obtain and even when such figures are available, they must be used with a good deal of discrimination. This applies especially to any comparison between locomotives of different designs, as many factors enter into any calculation as to maintenance costs.

Several questions immediately present themselves: What proportion of the total mileage was covered by the locomotive running light? What is the capacity of the locomotive? What is included in maintenance costs? For example, do they include alterations and abnormal expenses? What percentage do the shop expenses and cost of supervision bear to the wages? Is the figure given as the result of one special year's work, or is it the average of several years?

It is obvious that unless some idea can be obtained on the above points, actual figures as to maintenance can be of only a very limited utility. In spite of that fact, however, the few figures that are available in this paper are of interest. The maintenance cost of the double track locomotive of the Metropolitan District Railway, London, is given at 0.5d (10c) per locomotive mile. The capacity of this locomotive is

Table I.

Number	1	2	3	4	5	6	7	8	9
Name of railway	Mysore Gold Mining Company.	North-Eastern.	Harton Coal Company.	Detroit River Tunnel	New York, New Haven, & Hartford.	New York, New Haven, & Hartford.	St. Pölten Mariazell.	Lötschberg Tunnel.	New York Central and Hudson Riv'r
Class	B	B+B	B+B	B+B	B+B	1—B+B—1	C+C	C+C	2—D—2
Type	two-axle	double bogie	articulated	articulated bogie	articulated bogie	articulated bogie	double bogie	double bogie	..
Gauge	1 metre	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	760 mm.	4′ 8½″	4′ 8½″
Length over buffer beams	14′ 0″	35′ 0″	..	39′ 6″	37′ 0″	50′ 0″	33′ 9″	50′ 0″	43′ 0½″
Height to highest fixed point of roof, excluding current collector	9′ 4″	11′ 9″	..	14′ 0″	12′ 5″	13′ 10″	10′ 7″	13′ 6″	13′ 11½″
Overall width	6′ 8″	8′ 8″	..	10′ 2″	10′ 3″	10′ 3″	7′ 6½″	9′ 9″	10′ 0″
Weight on driving axles tons	16	56	40	88	71·4	81	47·6	90	..
Weight on pony axles tons	..	..	..	..	..	26	..	..	..
Total weight tons	16	56	40	88	71·4	107	47·6	90	..
Fixed wheel base	6′ 0″	5′ 6″	..	9′ 6″	7′ 0″	8′ 0″	7′ 10½″	13′ 2″	13′ 0″
Diameter of driving wheels	33″	36″	..	48″	63″	63″	800 mm.	52⅜″ (1,350 mm.)	44″
Diameter of pony wheels	..	..	..	..	..	36″	..	.	36½″
Maximum speed	about 16·5 m.p.h.	about 20 m.p.h.	..	35 m.p.h.	..	45 m.p.h.	50 km.p.h.	70 km.p.h.	about 60 m.p.h.
Distribution voltage	550	600	550	600/650	11,000	11,000	6,500	15,000	600
Frequency	C.C.	C.C.	C.C.	C.C.	25∿1 ph.	25∿1 ph.	25∿1 ph.	15∿1 ph.	C.C.
Number of motors	2	4	4	4	4	4	2	2	4
Type of motor	series	series	series	series	series compensated	series compensated	series compensated	series compensated	two-pole series
Rated horse-power per motor	50	150	75	300	192	170	250	1,000	..
Transmission	single gearing	single gearing	single gearing	twin gearing	single gearing	single gearing	single gearing	single gearing	direct drive
Gear ratio	6·25 : 1	3·27 : 1	6·5 : 1	4·37 : 1	..	4·1 : 1	..	3·25 : 1	..
Type of gearing	straight	straight	straight	straight	straight	straight	straight	triple helical	..
Tractive effort of all motors, corresponding to one-hour rating	8,400 lb.	12,800 lb.		about 37,000 lb.	14,800 lb. (continuous)	12,000 lb. (continuous)	...	28,800 lb.	..
Tractive effort of all motors at 25 per cent. adhesion	8,960 lb.	31,360 lb.	22,400 lb.	50,000 lb.	40,000 lb.	45,500 lb.	26,700 lb.	50,000 lb.	..
Speed at one-hour rating	about 8 m.p.h.	10 m.p.h.	..	about 12 m.p.h.	11·5 m.p.h. (at cont.r'ting	35 m.p.h. (at cont. rating)	..	42 km.p.h.	..
Gear velocity at one-hour rating	510 ft./min.	..	..	810 ft./min.	..	2,200 ft./min. (at cont. r't'g)	..	2,460 ft./min.	..
Gear velocity at maximum speed	1,300 ft./min.	..	..	2,360 ft./min.	..	2,830 ft./min.	..	4,100 ft./min.	..
Inclination of connecting rod to horizontal	..	..	..	..	..	..	..	4°	..
Length of shortest coupling rod	..	..	..	..	..	..	..	9′ 0′	..
Number of jack shafts	..	..	..	..	..	..	..	2	..
Control system	hand	electric Type M.	hand	electric Type M.	electro-pneumatic	electro-pneumatic	..	electric contactors	electric
Weight of electrical equipment tons	3	..	..	..	..	..	25·4	44	
Builders of mechanical part	Bagnall	Brush	Kerr Stuart	American Loco. Co. G.E. Co.	Baldwin Loco. Works Westing-house	Baldwin Loco. Works Westing-house	..	Swiss Loco. Works Oerlikon	American Loco. Co. G.E. Co.
Builders of electrical equipment	Siemens	B.T.H.	Siemens	.	1912	1912	Siemens	Nov., 1910	
Date of setting to work	end of 1910	May, 1905	..				Oct., 1911		

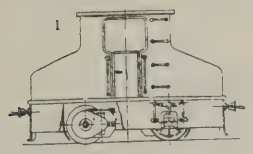


Fig. 1—Two-Axle 100 h.p. d.c. Locomotive

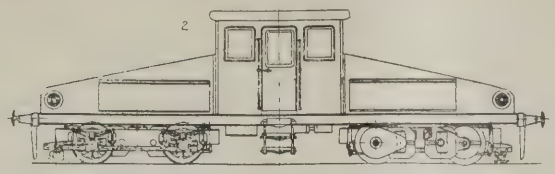


Fig. 2—Northeastern (England) 600 h.p. d.c. Locomotive

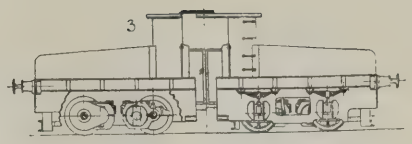


Fig. 3—Harton Coal Co., 300 h.p. d.c. Locomotive

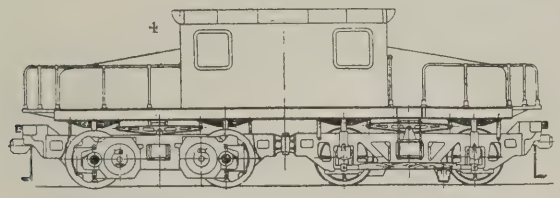


Fig. 4—Detroit River 1,200 h.p. d.c. Locomotive

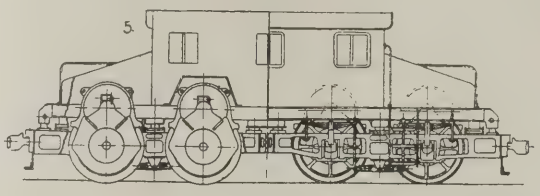


Fig. 5—N. Y., N. H. & H. 750 h.p. Single Phase Locomotive

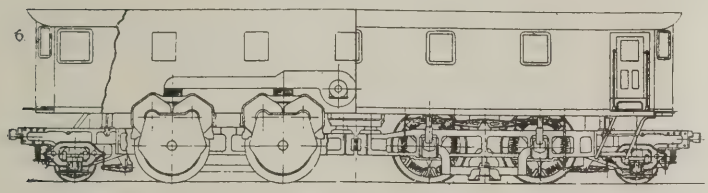


Fig. 6—N. Y., N. H. & H. 680 h.p. Single Phase Locomotive

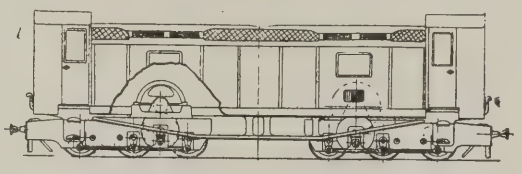


Fig. 7—St. Palton Mariazell 500 h.p. Single Phase Locomotive

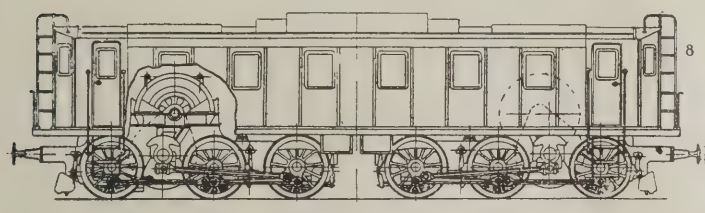


Fig. 8—Lotschberg Tunnel 2,000 h.p. Single Phase Locomotive

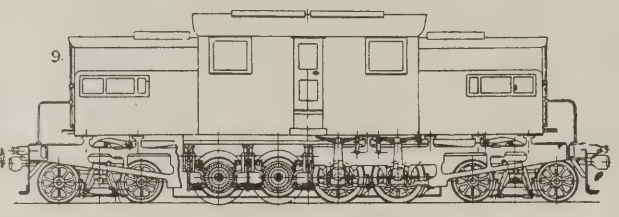


Fig. 9—New York Central 600 Volt d.c. Locomotive

Table I.—*Continued*

10 New York, New Haven, & Hartford	11 Valtellina.	12 Simplon Tunnel	13 Wissental (Baden State).	14 Midi, France.	15 Lötschberg Tunnel.	16 Pennsylvania.	17 Prussian State.	18 Prussian State.	19 Prussian State.	20 Mittenwald	[21] Wiesental (Baden State).	22 Prussian State.	23 Kiruna Riksgraensen.
1—B+B—1	1—C—1	o—D—o	1—C—1	1—C—1	1—B+B—1 articulated	2—B+B—2 articulated	2—B—1	0—D—0	1—D—1	1—C—0	1—C—1	1—1C—	1—C+C—1 articulated
..	..	..	..	..	..	..	..	..	..	..	..	..	..
4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″	4′ 8½″
..	11·54 m. (over buffers)	10·4 m.	13·03 m.	12·0 m.	14·45 m.	64′ 11″	11·23 m.	9·2 m.	12·8 m.	9·0 m.	11·1 m.	11·8 m.	..
..	3·66 m.	3·685 m.	4·38 m.	4·2 m.	4·4 m.	14′ 8″	3·97 m.	3·8 m.	4·2 m.	4·0 m.	4·4 m.	..	..
..	..	2·9 m.	3·1 m.	3·14 m.	3·0 m.	10′ 6″	3·03	1·98 m.	..	..	3·15 m.	..	..
..	42	68	42	54	68	87	30·25	60	56	40·8	41·4	45	..
..	20	..	23	31	25	53	42	..	23·5	12·25	23·6	26	..
..	62	68	65	85	93	140	72·25	60	79·5	53·05	65	61	..
..	4·70 m.	4·60 m.	3·5 m.	3·60 m.	2·88 m.	7′ 2″		4·8 m.	5·6 m.	4·0 m.	4·0 m.	..	..
62″	1,500 mm.	1,250 mm.	1,200 mm.	1,310 mm.	1,270 mm.	6′ 0″	1,600 mm. =63″	1,050 mm. =41·4″	1,150 mm. =45·2″	1,034 mm. =40·7″	1,050 mm. =41·4″	1,600 mm. =63″	1,100 mm. =43·3″
..	800 mm.	..	850 mm.	850 mm.	850 mm.	3′ 0″	1,000 mm. =3′ 3⅜″	..	850 mm. =33·5″	870 mm. =34·2″	850 mm. =33·5″	1,000 mm. =3′ 3⅜″	720 mm. =28·3″
..	64 km.p.h.	70 km.p.h.	75 km.p.h.	75 km.p.h.	75 km.p.h.	..	135 km.p.h. =83·8m.p.h.	60 km.p.h. =37·3m.p.h.	83 km.p.h. =51·5m.p.h.	..	90 km.p.h. =56 m.p.h.	110 km.p.h. =68·4m.p.h.	..
11,000	3,000/3,300	3,000/3,300	10,000	15,000	15,000	600	10,000	10,000	10,000	15,000	10,000	10,000	..
25∿1 ph.	15∿3 ph.	16∿3 ph.	15∿1 ph.	16⅔∿1 ph.	15∿1 ph.	C.C.	15∿1 ph.	15∿1 ph.	15∿1 ph.	16⅔∿1 ph.	15∿1 ph.	15∿1 ph.	1 ph.
4	2	2	2	2	2	2	1	1	2	1	2	1	2
series compensated	cascade induction	four-speed induction	series c'mp'ns't'd	c'mpens't'd repulsion	c'mpens't'd repulsion	series	series compens't'd	series compens't'd	series compens't'd	compens't'd repulsion	series compens't'd	series compens't'd	series compens't'd
250	400	850	525	800	800	2,000	1,000	800	1,250	800	525	1,800	12
direct drive	Scotch yokes	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods	connecting rods
..	..	..	..	..	..	..	..	..	..	..	..	..	..
8,600 lb.	7,500 lb.	14,500 lb.	8,820 lb.	..	17,600 lb.	..	12,000 lb.	10,800 lb.	19,800 lb.	16,000 lb.	..	11,000 lb.	19,200 lb.
..	23,500 lb.	38,000 lb.	23,500 lb.	30,000 lb.	33,000 lb.	49,000 lb.	17,000 lb.	33,600 lb.	31,500 lb.	45,000 lb.	..	25,000 lb.	..
43·5 m.p.h.	64 km.p.h.	71 km.p.h.	70 km.p.h.	..	40 km.p.h.	..	50 km.p.h. (31·3 m.p.h.)	44·5 km.p.h. (27·7 m.p.h.	76 km.p.h. (47·2 m.p.h.)	30 km.p.h. (18·7 m.p.h.)	..	98 km.p.h. (61 m.p.h.)	..
..	..	..	..	..	..	..	..	..	..	..	..	*a*	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	12°	10°	49°	46·5°	73·6°	41·5°	90°	49°	34°	45°	49°	..	36°
..	..	1,550 mm. =5′ 1″	..	1,500 mm. =4′ 11″	1,300 mm. =4′ 3″	5′ 6″	..	900 mm. =35·5″	1,050 mm. =41·3″	about 1,050 mm. =41·3″	about 860 mm. =33·9″	..	..
..	..	..	2	2	2	2	1	1	1	1	1	1	2
electro-pneumatic	pneumatic	pneumatic	induction regulator	electric contactors	electric contactors	electro-pneumatic	induction regulator	induction regulator	induction regulator	electric contactors	induction regulator	induction regulator	electric contactor
..	..	35	34	49	49	..	..	..	..	26·8	..	..	..
Baldwin Loco. Works	..	..	..	Henschel, Cassel	Krauss, Munich	Baldwin Loco. W'rks	..	..	..	..	..	..	..
Westing-house	Ganz	Brown, Boveri	Siemens	A.E.G.	A.E.G.	Westing-house	Siemens	Siemens	Siemens	A.E.G.	Siemens	Siemens	Siemens
..	..	1901/1908	..	1912	Nov., 1910	Oct., 1909	..	..	..	Oct., 1912	..	..	..

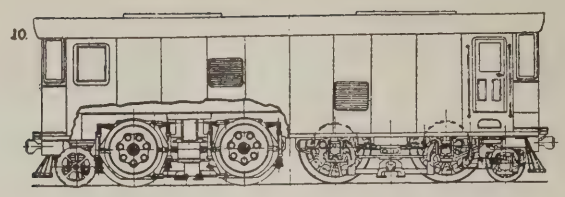


Fig. 10—N. Y., N. H. & H. 1,000 h.p. Single Phase Locomotive

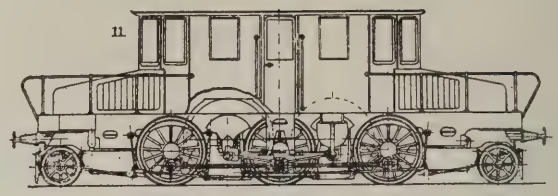


Fig. 11—Valtellina 3-Phase 800 h.p. Locomotive

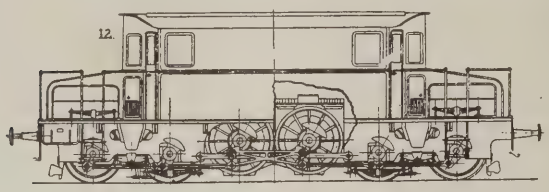


Fig. 12—Simplon Tunnel 3-Phase 1700 H.p. Locomotive

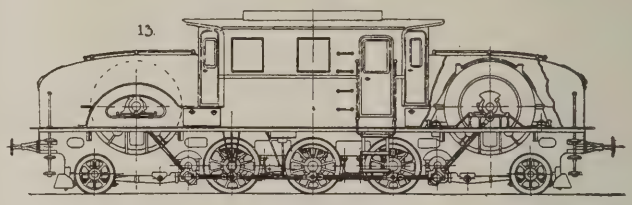


Fig. 13—Wiesental (Baden State Ry.) Single Phase 1,050 h.p. Locomotive

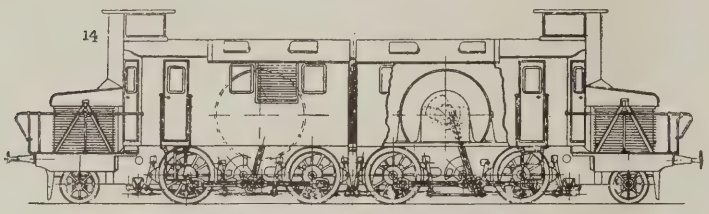


Fig 14—Midi, France, Single Phase 1,600 h.p. Locomotive

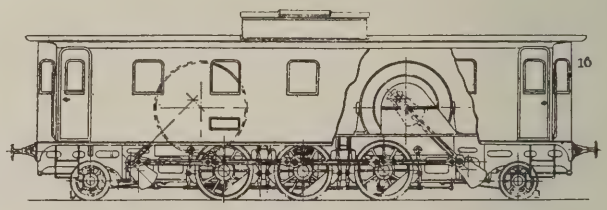


Fig 16—Penn. D. C. 4,000 h.p. Locomotive

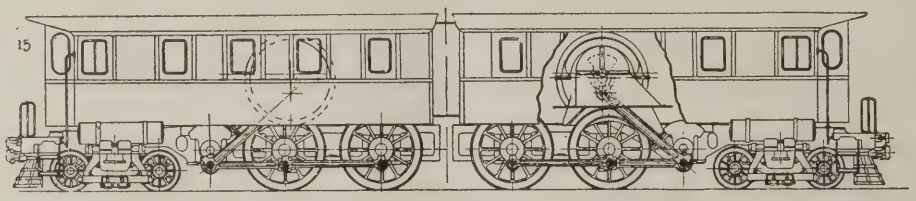


Fig. 15—Lotschberg Tunnel Single Phase 1,600 h.p. Locomotive

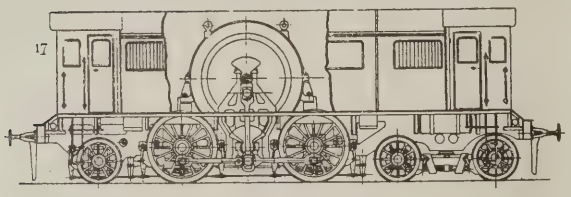


Fig. 17—Prussian State Rys. Single Phase 1,000 h.p. Locomotive

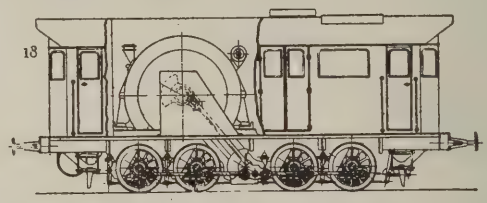


Fig. 18—Prussian State Rys. Single Phase 800 h.p. Locomotive

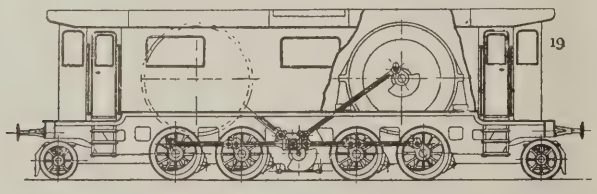


Fig. 19—Prussian State Rys. Single-Phase 2,500 h.p. Locomotive

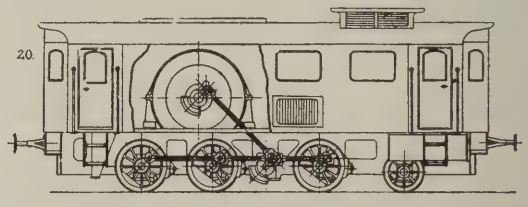


Fig. 20—Mittenwald Single Phase 800 H.p. Locomotive

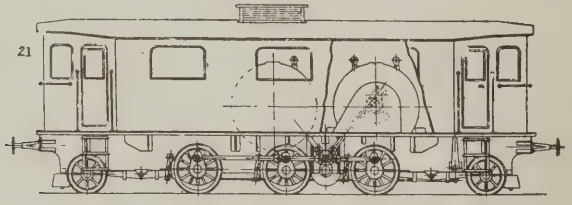


Fig. 21—Wisestental (Baden State Ry.) Single Phase 1,050 h.p. Locomotive

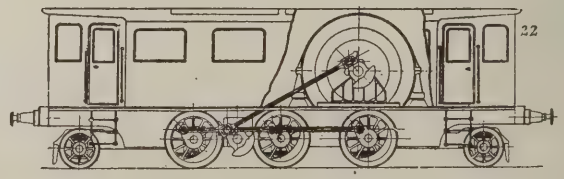


Fig. 22—Prussian State Rys. Single Phase 1,800 h.p. Locomotive

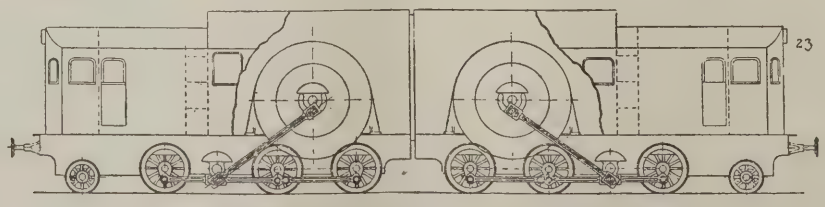


Fig. 23—Kiruna Riksgraensen Single Phase 2,400 h.p. Locomotive

800 horsepower. For the New York Central locomotives, the average cost for four years is 3c per locomotive mile, for the Pennsylvania Railroad double locomotives, the cost is slightly less than 6c. The New York, New Haven & Hartford locomotives are of several different designs and maintenance costs vary accordingly from 1½c to 6c per locomotive mile. Only provisional suggestions can be made in regard to each of the different types because in any particular case the whole design hangs together, the mechanical arrangement depending upon the dimensions of the motor and vice versa.

Before the motor itself can be designed to suit any suggested mechanical arrangement of the running gear, numerous questions must be definitely decided —i. e., is the motor intended for high or low-tension continuous current, three-phase or single-phase alternating current? What is the maximum locomotive speed, the average speed, the maximum and the average torque, the speeds corresponding with the maximum and average values of the torque, etc.? All these questions must be dealt with before a design can be worked out, and can only be answered after careful study of the local conditions and the specified duty of the locomotive. The following somewhat general remarks, however, may serve to illustrate by concrete examples some of the considerations brought forward in this paper:

Switching Locomotive.—This may be a double-truck locomotive with a total weight of about 60 tons, equipped with four standard geared motors with an aggregate capacity of about 600 horsepower on the one-hour rating. It should be of the steeple type with central driver's compartment and sloping ends.

Freight Locomotive.—This also may be of the double-truck steeple type, as the maximum speed is not required to exceed 45 miles per hour. It will be equipped with four-geared motors with an aggregate capacity of about 1,200 horsepower on the one-hour rating.

Local Passenger Locomotive.—The maximum suggested speed being 65 miles per hour, it is advisable that leading and trailing radial axles, or single-axle truck, should be provided. For the driving axles several alternatives suggest themselves. For purposes of adhesion, two driving axles carrying 16 tons per axle should be sufficient. These two axles might perhaps be driven by two pairs of geared motors, each pair geared to a single gear wheel, as in the articulated truck locomotive supplied by the Westinghouse Company to the New York, New Haven & Hartford Railroad. Each motor would have a one-hour rating of about 275 horsepower, and the design would have to be carefully worked out before an opinion could be expressed whether at the maximum speed the gear velocity would be excessive. If the large number of motors were objected to, the alternative would be to dispense with gearing altogether, and to drive by means of connecting rods. In this case, assuming the maximum angular velocity of the driving wheels to be 500 revolutions per minute, the diameter would be about 46 inches. If the limiting peripheral velocity is assumed as 44 meters per second (8,600 feet per minute), the armature diameter will be 1,680 millimeters. A single motor of 1,100 horsepower could easily be built with an armature of this size, and could be connected to the driving axles through the intermediary of a jack shaft. Or it would be possible to use two 550 horsepower motors running at a comparatively low speed, both coupled to a central jack shaft between the driving axles.

Class	Switching		Freight		Local passenger			Express passenger		
Tractive effort, lb.	28,000		28,700		10,000	14,700	5,000	24,000	12,000	8,000
Speed, m.p.h.	10		17.5	(25)	30	30	55	40	60	75
Corresponding horsepower	750	1,340		(2,300)	775	1,180	735	2,550	1,920	1,600
Limiting speed, m.p.h.	20		45		.....	65		.....	85	....

Express Passenger Locomotive.—This locomotive should have leading and trailing two-axle trucks and three driving axles. To permit of high speeds being attained, the driving wheels should have a diameter of not less than about 60 inches. The equipment may then consist of two 1,200 horsepower motors, probably mounted in the body of the locomotive and driving together on to a jack shaft between the central and one of the outer driving axles. A possible alternative is to connect the two motor axles to the central driving axle by Scotch yokes. The best arrangement, however, can only be decided on after suitable motors have been worked out to meet the different conditions.

Maintenance Costs of Electric Locomotives

The Galt, Preston & Hespler Railway Company, Ltd., Preston, Ontario, placed the 40-ton Baldwin-Westinghouse Locomotive herewith illustrated, in service on November 20th, 1910, and since that date has been in continuous operation, twenty-four hours every day except Sundays, averaging about 150 hours per week. This service includes hauling practically every kind of freight in standard steam railroad rolling stock, between the Canadian Pacific Railroad at Galt, Berlin and Waterloo, a distance of from 12 to 14 miles north.

Although the haul is not so very long there are a number of 2 to 2½ per cent grades, from one to two miles long.

The maximum number of cars hauled in one train is about 25, the average number being 15, and the tonnage per train is about 200 tons or on four trips of road service per day, 2,000 tons.

It is hardly possible to estimate exactly the total mileage as the greater part of the time, 16 hours per day, the locomotive is in switching service. No record is kept of the tonnage and mileage, but the switching mileage would easily equal half, if not three-quarters, of the road service.

This locomotive is equipped with four Westinghouse No. 308-B-2 commutating-pole, 600-volt, railway motors, rated at 120 h. p., and unit switch control.

Inspection and Maintenance.

The locomotive is given one-half hour inspection every twenty-four hours, and about five or six every Sunday when making light repairs, such as applying brake shoes, changing wheels for tire running and inspection of motors, air-brakes, and control equipment. Tires have been turned twice since this locomotive went into service and the total repair account to date is given below:

Air compressor (principally due to armature and field trouble due to low trolley voltage)	$170.00
Tire turning	45.00
Motor axle bearings	30.00
Unit switch control	50.00
Trolley parts, wheels, harps, poles and bases	110.00
Brake shoes	270.00
Miscellaneous	30.00
Total (from Nov. 30, 1910, to July 14, 1913)	$705.00

The total, $705.00, for repairs on this locomotive covering a period of over 2½ years is considered a very good record by the operating company in view of the large amount of service received.

The Engineering Problem of Electrification

By A. H. Armstrong

The broad question of whether electrification will show an attractive return upon the large capital investment required can best be determined by a detailed investigation of the local conditions obtaining in any given case. Any estimate of a general character is at best more or less misleading when applied to a specific problem. The electric locomotive possesses many operating characteristics not shared by the steam engine and its introduction opens up possibilities in operating methods that may make it desirable to effect sweeping changes in train operation as now carried on with steam engines. Until one or more engine divisions are electrically operated, perhaps we may not fully appreciate what it means to the railway operator to be relieved of many of the limitations of the steam locomotive.

For example, given an electric locomotive capable of hauling an 800 ton passenger train at sixty miles per hour on level track and without assisting locomotives, haul the same train up gradients of 2 per cent at a speed of twenty-five miles per hour, it is possible to make radical improvements in schedule. When it is considered furthermore that such an electric locomotive requires no stops for fuel and water and can operate 1,200 miles or more between inspections, it is evident that electrification calls for considerable readjustment of steam railway traditions.

Failure to fully grasp the possibilities of electrical operation may result in running up the first cost of proposed electrification to an extravagant total upon which no adequate return is possible. So much local color is required to intelligently discuss the question of "will it pay to electrify," that no attempt will be made in this paper to discuss the financial aspect of the matter. The several important installations now under construction and the even larger projects upon which favorable decision has been reached, all point to the fact that electrification must be attractive in some instances at least. There are, however, certain fundamental data governing the operation of all electric locomotives and it is the purpose of this paper to discuss some of the engineering questions involved.

At the outset, it is found that the electrical engineer has perfected several types of locomotives and different methods of distributing electric power to them, thus giving rise to what is known as several different "systems of operation." The term "system" is generally applied to the combination of locomotive and trolley or third rail distribution as the question of power generation and transmission is common to all.

It is proposed to replace the steam engine with a type of motive power that offers superior advantages in the hauling of heavy trains. In other words, the electric locomotive itself constitutes the main argument in favor of electrification, and no marked excellence of distribution system can offset the failure of the electric motive power. The steam locomotive it is proposed to replace is a highly developed machine of great reliability and the result of the experience born of a great many failures. It cannot be too strongly emphasized therefore that the electric motive power is the controlling factor in main line electrification, a point of view that is sometimes overlooked.

The three electric systems considered for main line electrification are as follows:

1. Single-phase—alternating current.
2. Split-phase—alternating current.
3. High voltage—direct current.

The single-phase commutating motor has been in operation upon interurban electric railways for some years, and a study of the history of these installations reveals some of the fundamental reasons why this type of motive power has not been more generally adopted. It has been found that the initial expense and cost of upkeep of rolling stock equipped with single-phase commutating motors is fully double that of cars having the same seating capacity and equipped with direct current motors. No new installations have been made for the past two years, and the several single-phase roads are being changed over to direct current as fast as financial conditions will permit. Following is a list of the single-phase installations and on those roads starred the single-phase motors have been replaced with the direct current type.

The introduction of the single-phase system was a result of the success of suburban and interurban electric railway operation and the extension of these lines over large areas, thus bringing into prominence the question of economical power distribution. It was recognized that a voltage higher than the commonly accepted standard of 600 volts was desirable upon the trolley in order to minimize the cost of installing feeder copper and substations. While the single-phase motor was being developed and installed upon interurban railways careful attention was also being given to the question of the possibility of using direct current motor equipments at higher voltages and resulted in the installation of the first 1200-volt road, the Indianapolis & Louisville Traction Railway, operated in 1907. The success attending this operation lead to other similar installations at both 1200 and 1500 volts until it is now generally recognized that the high voltage direct current system is without a competitor for all classes of suburban and interurban electric railways. It is a safe prediction to make that no more single-phase motor equipments will be placed in operation in this country on new roads unless these roads virtually form an extension of existing systems.

Following is listed the several high voltage direct current installations in the United States and Canada.

The history of the battle of the systems and the elimination of the single-phase motor as being unsuitable for the equipment of light electric railways has an important bearing upon the selection of systems for main line electrification. The limitations of the single-phase motor that lead to its failure in the interurban railway field do not appear to be lessened when considering it for locomotive equipment with the result that it is in use on but three of the twelve roads that are truly representative of electrified steam roads operating large electric locomotives.

There are other electrified steam lines, but the service on them more nearly approaches that of high class electric interurban railways.

Abstract of paper presented before the December meeting of the Canadian Society of Civil Engineers.

Single-Phase Railway Installations in United States and Canada

Name of Railway	Year
Indianapolis & Cincinnati	1904
*Atlanta & Northern Ry.	1905
*Illinois Traction Co.	1905
Long Island R. R.—Sea Cliff Division	1905
San Francisco, Vallejo & Napa Valley, California	1905
*Warren & Jamestown	1905
Westmoreland County Traction, Derby to Latrobe, Pa.	1905
Spokane & Inland Empire R. R.	1906
*Toledo & Chicago Ry.	1906
*Anderson Traction, S. C.	1907
Erie R. R.	1907
Fort Wayne & Springfield	1907
*Milwaukee Electric Railway	1907
New York, New Haven & Hartford	1907
*Pittsburg & Butler	1907
Richmond & Chesapeake Bay	1907
Windsor, Essex & Lake Shore	1907
*Baltimore & Annapolis, S. L.	1908
Chicago, Lake Shore & South Bend	1908
Colorado & Southern:	
Denver & Interurban R. R.	1908
Grand Trunk Ry.:	
Sarnia-Port Huron Tunnel	1908
Hanover & York Ry., Pa.	1908
Shawinigan Ry., Quebec	1908
Visalia Electric Ry., California	1908
*Washington, Baltimore & Annapolis	1908
Rock Island Southern:	
Rock Island to Monmouth	1910
New York, Westchester & Boston	1911
Boston & Maine:	
Hoosac Tunnel	1911

*Changed from alternating current to direct current motors.

High Voltage D. C. Ry. Installations in U. S. and Canada

Road	Voltage	No. of Equipments	Date
I. & L. T. Ry., Scottsburg, Ind.	1200	13	Oct., 1907
Cent. Cal. Trac. Co. Stockton Cal.	1200	22	June, 1908
P., H., B. & N. C. Ry., Bidenau, Pa.	1200	30	July, 1908
W., B. & A. Elec. Ry., Baltimore, Md.	1200	47	Feb., 1910
M. E. Ry. & Lt. Co., Milwaukee, Wis.	1200	32	Mar., 1910
A. V. Ry. Co., Presque Isle, Me.	1200	6	July, 1910
O., A. & E. Ry., San Francisco, Cal.	1200	25	1910
S. C. Ry. Co., Johnstown, Pa.	1200	10	1910
S. L. Elec. Ry. Co., Saybrook, Conn.	1200	22	Sept., 1910
S. P. Co. (Oakland, Alameda & Berkeley Div.), Cal.	1200	82	April, 1911
Ft. Dodge, D. M. & S. Ry., Boone, Ia.	1200	29	Sept., 1911
S. T. & P. Co., New Iberia, La.	1200	3	May, 1912
O. E. Ry., Portland, Ore.	1200	72	July, 1912
D. & M. Ry., Davenport, Ia.	1200	7	Aug., 1912
K. C., C. C. & St. J. Ry., Kan. C., Mo.	1500	22	June, 1913
P. T. Co., Charlotte, N. C.	1500	43	1913
N., G. Inter. Ry., Nashville, Tenn.	1200	6	April, 1913
Butte, Anac. & Pac. Ry., Butte, Mont.	2400	17	June, 1913
United Railways Co., Portland, Ore.	1200	8	June, 1913
So. Trac. Co., Dallas, Tex.	1200	30	Oct., 1913
Pittsbg. & But. Ry. Co., Pittsbg., Pa.	1200	13	1913
Pac. Elec. (San Bernardino Div.), Los Angeles, Cal.	1200	54	Building
Tidewater So. R. R., Stockton, Cal.	1200	4	1913
Portland, E. & E. Ry., Portland, Ore.	1500	38	Building
So. Ill. Ry. & Pr. Co., Harrisburg, Ill.	1200	5	Sept., 1913
Jefferson Co. Tr. Co., Beaumont, Tex.	1200	7	Building
St. Paul So. Elec. Ry., St. Paul, Minn.	1200	5	Building
	2400	20	Building
Mich. United Tr. Co., Jackson, Mich.	1200	40	Building
Can. Nor. Ry. Co., Montreal, Can.	2400	14	Building
Can. Pac. Ry. Co., Rossland, B. C.	2400	4	Building

All the above roads are operating with the highest degree of success and no change of type of equipment has been made or any such contemplated.

The so-called "split-phase" system is a comparatively new comer in the electric traction field and it has not yet been subjected to the test of actual operation. The proposed system offers many attractive features, however, and it is worthy of careful study in order to understand its fitness for heavy electric railway service. From experimental tests made, it seems reasonably certain that the split-phase locomotive can meet the demands of commercial operation with satisfactory reliability.

Confronted with the problem of main line electrification and the demand for a distributing system which would provide for the economical distribution of large units of power over an extended area, the need of higher direct current voltage was appreciated and resulted in the first installation of 2400 volts direct current upon the Butte, Anaconda & Pacific Railway, first operated May 28th of this year. This installation marks an epoch in electric railway progress, as its success offers substantial proof that direct current motor equipments can be constructed at a reasonable cost and operated in an efficient and reliable manner with trolley potentials as high as 2400 volts.

Main Line Electrification

U. S. and Canada

Installation	Year	Type Loco.	System	Voltage
St. Clair Tunnel.	1908	Geared	Single-phase a. c.	3300
N. Y., N. H. & H.	1907	Gearless	Single-phase a. c.	11000
Hoosac Tunnel.	1911	Geared	Single-phase a. c.	11000
Cascade Tunnel.	1909	Geared	Three-phase a. c.	6600
*Norfolk & Western	1914	Geared side rod	Split-phase a. c.	16500
B. & O. Tunnel.	1895	Geared	Direct current	600
N. Y. Central.	1906	Gearless	Direct current	600
Detroit Tunnel.	1910	Geared	Direct current	600
Penn. Terminal.	1910	Side rod	Direct current	600
Butte, Anac. & Pac.	1913	Geared	Direct current	2400
*Canadian Nor.	1914	Geared	Direct current	2400
*Canadian Pac.	1914	Geared	Direct current	2400

*Under construction.

It has been characteristic of the installations operating at 1200 and 1500 volts that the reliability of the direct current motive power has been in no way impaired by reason of using a higher trolley voltage, in fact, the maintenance of 1200 volt motor equipments shows no increase over that of 600 volt equipments. A brush life of over 150,000 miles gives evidence of good commutator performance with practically no wear and the increased insulation and creepage distance provided has been ample to ensure reliability and low cost of maintenance.

The success of high voltage direct current installations has not been marred by a single instance of failure due to fundamental defect in the type of apparatus used, and justifies the conclusion that the 2400 volt, 1200 volt and the 600 volt direct current equipments are all part of the same general direct current system, and that the only

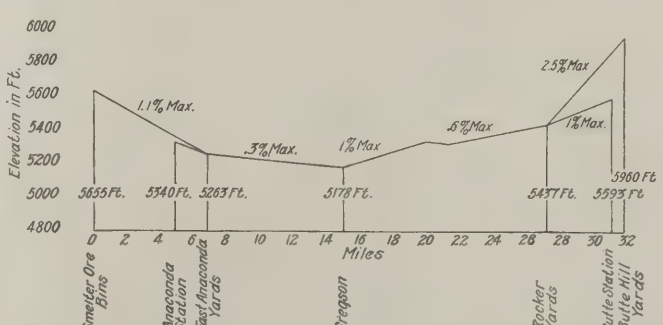


Fig. 1—Profile of Butte, Anaconda & Pacific Railway

difference is the need of more insulation in one case than in the other.

Fully appreciating the grave responsibility of selecting a type of motive power for a proposed electrification that holds promise of special fitness for the immediate service contemplated and also is capable of meeting the demands of unlimited future extensions, this paper will briefly touch upon the comparative characteristics of the split-

phase and 2400 volt direct current systems of operation. The choice seems to lie between split-phase and direct current inasmuch as the history of the single-phase motor equipment does not seem to justify its further consideration for heavy electric railroading.

The general scheme of distribution to the split-phase locomotive is shown in Fig. 5 which has special application to western railways where 60 cycle power supply is universally standardized. A corresponding diagram of the 2400 volt direct current system is shown in Fig. 6, this also being adapted to 60 cycle power supply.

Starting first with a comparison of the two types of locomotives it is necessary to make some general assumption as regards service conditions in order to draw conclusions as to relative locomotive characteristics. The electric locomotive is capable of being constructed in very large units, but convenience in shopping and simplicity in construction both point to a unit of approximately 100 tons total weight on drivers. These 100 ton units can be coupled together and operated as a single locomotive of any desired capacity, though probably a two unit locomotive weighing 200 tons and giving a starting tractive effort of 120,000 lbs. is as large as the draft gear will stand.

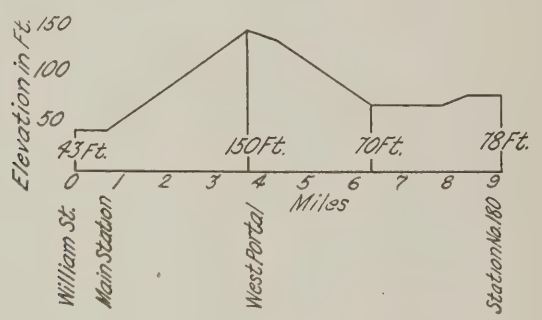


Fig. 2—Profile of Norfolk & Western Railway—Elkhorn Division

CONDITIONS ON A 2% RULING GRADIENT.

Tractive effort due to 2 per cent grade	40 lb.
Tractive effort due to train resistance	6 lb.
Tractive effort due to curve resistance	2 lb.
Total per ton	48 lb.
Total weight on drivers	200,000 lb.
Rating at 18 per cent coefficient of adhesion	36,000 lb.
Gross train weight	750 tons
Trailing train weight	650 tons
Speed	15 m. p. h.
Net output at drivers	1450 h. p.

A maximum load of 50,000 lbs. per axle has been assumed as being within acceptance of good practice. The question of speed on ruling grade is one subject to local requirements, but in general a speed of 15 m.p.h. on 2 per cent grade is as high as desirable on roads of moderate tonnage.

Owing to the moderate speeds at which a freight locomotive will operate, it is entirely feasible to consider a construction wherein the motors are geared direct to the driving axles by twin gearing, in this respect following the practice of the Detroit Tunnel, Cascade and B. A. P. locomotive which has proven very successful.

For the purpose of this comparison, it is assumed that both split-phase and direct current locomotives will be of similar construction and employ twin geared motors of equal weight and efficiency. A comparison of weight distribution in the two types of locomotives is presented herewith.

As the direct current locomotive of 100 tons carries no ballast, it is evident that the 40,000 lbs. comprising the phase converter and transformer of the split-phase locomotive must be carried on idle wheels together with the additional weight of cab and running gear required to carry this excess weight. The net result is a split-phase locomotive of fully 35 per cent more weight than a direct current locomotive of equal capacity and of similar construction. This weight comparison is based upon the assumption that 50,000 lbs. per axle constitutes the limit allowable, thus forcing the introduction of guiding

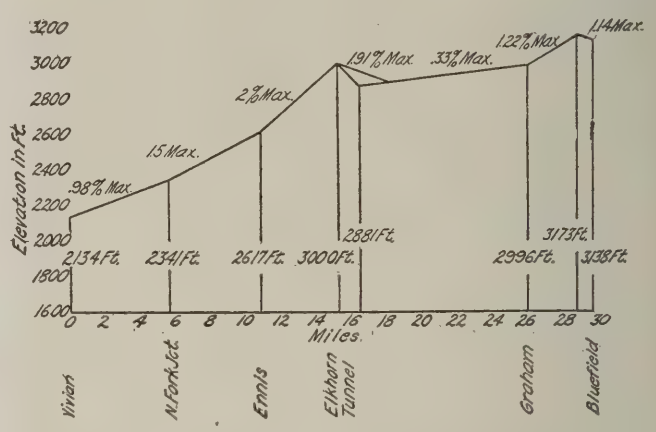


Fig. 3—Profile of Canadian Pacific Railway—Rossland Subdivision

axles to carry the excess weight of the split-phase equipment. For locomotive construction of less capacity, permitting the split-phase to come within axle weight limits, both types of locomotives would comprise four axles with no guiding wheels and the split-phase locomotive may not total more than 20 per cent more weight than the equivalent direct current type.

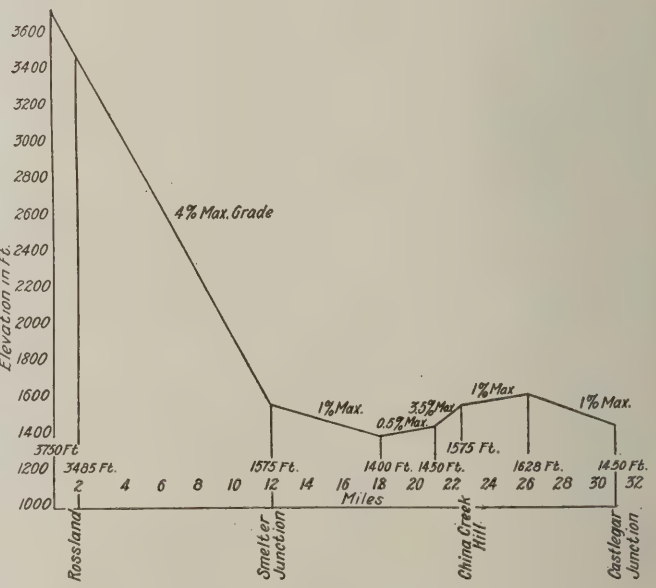


Fig. 4—Profile of Canadian Northern Railway—Montreal Tunnel & Terminal Electrification

It is evident that the split-phase locomotive is not only considerably heavier for equal capacity, but also more complicated and inefficient than the direct current locomotive.

COMPARATIVE WEIGHT EFFICIENCY
Freight Locomotives

	Split-Phase	2400 Volts Direct Current
Rated t.e. on ruling grade	36,000 lb.	36,000 lb.
Gross train weight	750 tons	750 tons
Trailing train weight	615 tons	650 tons
Per cent trailing to gross	82%	86.7%
Weight efficiency	94.7%	100%

The split-phase locomotive motor is of the multiphase induction type and not adapted to gearless construction except by the introduction of quills and springs. This form of construction has not been so successful in operation as to justify considering its general adoption. It is assumed, therefore, that in order to get a locomotive of good riding qualities at high speeds, it is necessary to resort to side rod drive from a jack shaft and house the

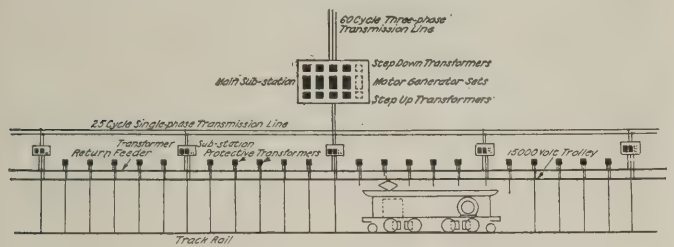


Fig. 5—General Scheme of Split-Phase Alternating Current System

motors in the cab. In this comparison it is assumed that motors drive the jack shaft through gears rather than by rods as offering a lighter form of construction requiring less space. The same form of drive is equally available with direct current motors, but gearless construction offers great advantages such as extreme simplicity, accessibility and high efficiency so that comparison will be based upon geared side rod split-phase and gearless direct current motor locomotives.

It is reasonable to expect the efficiency of mixed passenger and freight locomotive operation to approximate 85 per cent for direct current and not much exceeding 68 to 70 per cent for split-phase locomotives.

PASSENGER LOCOMOTIVE EFFICIENCY
Detailed Comparison

	Split-Phase		2400 Volts Direct Current	
	Ruling Grade	Level	Ruling Grade	Level
	Per Cent		Per Cent	
Motors and gears	89.3	83.0	87.5	94.0
Blower	97.8	84.8	97.9	95.5
Starting resistances	98.6	97.8	99.2	99.3
Phase converter	96.3	94.0	....	....
Transformer	98.0	96.0	....	....
Wheel correction	98.0	98.0	....	....
Weight efficiency	92.5	92.5	....	....
Jack shaft	97.0	93.0	....	....
Side rods	97.0	93.0	....	....
Combined efficiency	69.3	54.5	85.0	89.2
Average of grade and level	61.9		87.1	

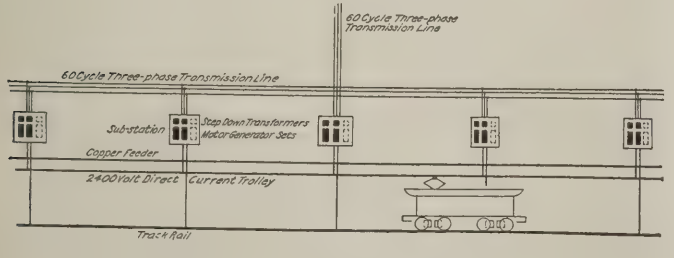


Fig. 6—General Scheme of 2,400-Volt Direct Current System

Before concluding the general discussion of the locomotive it is necessary to touch upon the question of braking. One of the strongest arguments advanced for the adoption of the induction motor locomotive is that this type of motor offers an ideal electric brake by reversing its function on down grade and returning power to the trolley circuit. A regenerative braking method of control has been perfected for use with the direct current motor which offers even greater advantages in service operation than induction motor braking. Just as the direct current locomotive is the more efficient in hauling a given trailing tonnage so also it will return to the system a large percentage of the mechanical power given the locomotive by the descending train. Hence whatever claims are advanced for regenerative electric braking with the split-phase locomotives are even more applicable to the direct current type.

Referring again to Figs. 5 and 6, showing the general plan of distribution respectively for the split-phase and direct current systems, it is of interest to compare the two in order to see how much of the split-phase locomotive loss is recouped by its more efficient distribution system. The following comparison is therefore submitted.

EFFICIENCY OF DISTRIBUTION SYSTEM.
Detail Comparison.

	Split-Phase Per Cent	2,400 Volts Direct Current Per Cent
Step-down transformers	97.5	96.5
Motor-generator sets	87.0	81.0
Step-up transformers	97.5	....
Railway transmission line	96.0	96.0
Line transformers	96.0	....
Protective transformers	96.0	....
Trolley, track and feeders	96.0	88.0
Combined efficiency	70.5	66.0

Protective transformers appearing in above table are for the purpose of neutralizing the inductive disturbance

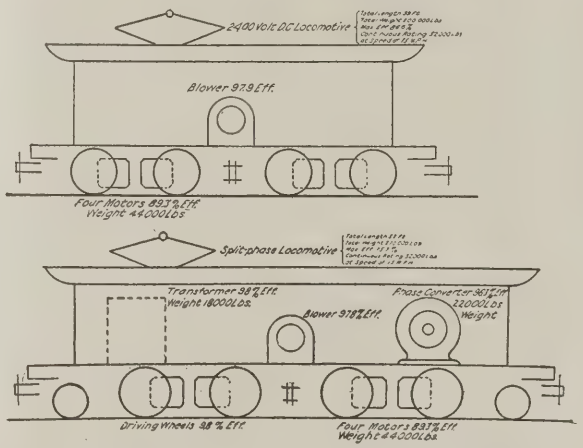


Fig. 7—Comparative Elevations of Split-Phase and 2,400-Volt Direct Current Locomotives of Equal Capacity

caused by single-phase trolley upon neighboring telephone, telegraph and signal circuits.

There is every reason to expect that the split-phase system will demand fully 15 per cent more power input than the direct current system of 2400 volts for equal trailing tonnage movement, actual figures depending upon the proportion of freight and passenger tonnage. This figure is based upon 60 cycle power supply for the reason that many of the immediate electrification projects under construction or contemplated are located in territories where this frequency is firmly established.

TOTAL EFFICIENCY.
Distribution System and Locomotive.

	Split-Phase Per Cent	2,400 Volts Direct Current Per Cent
Freight Service—		
Distribution	70.5	66.0
Locomotives	73.1	84.3
Combined efficiency	51.5	55.7
Passenger Service—		
Distribution	70.5	66.0
Locomotives	61.9	87.1
Combined efficiency	43.6	57.5

Where 25 cycles is available, single-phase power may

feasible. The third rail offers advantages in accessibility be taken direct from the three-phase supply provided phase and voltage balance is maintained by suitably located substations containing step down transformers and phase converters. Direct current supply will be more efficiently obtained through rotary converters in place of motor-generator sets. The efficiency of the distribution system, as given above, will therefore need correction for 25 cycle power supply, but will result in no material change in the relative efficiency figures quoted for the two systems.

A study of the general plant of distribution as given in Figs. 5 and 6 discloses the fact that where 60 cycle power supply is available at attractive rates, the general statement can be safely made that the total amount of electrical apparatus is greater and therefore the first cost higher and efficiency lower with the split-phase than with the direct current locomotive system. Nor is this statement modified to any extent in the event that power supply is obtained from a 25 cycle three-phase source, as it will be the exception rather than the rule that any power company will be found willing to furnish single-phase power from its balanced three-phase circuit when the pernicious effect upon the general distribution system of a violently fluctuating low power-factor single-phase load is fully understood.

As the inductive interference of the single-phase trolley is proportional to the intensity of the current and distance it is transmitted, it is to be expected that a maximum disturbance will result in the case of mountain grade divisions where the current input to trains approaching 3000 tons gross weight is several times that thus far met with in any single-phase trolley installation now operating. No cost estimate of single-phase trolley systems is therefore complete without including a liberal allowance for telephone and telegraph protective devices. This cost will probably not be less than $2,500.00 per mile of route and may even greatly exceed this figure. Even with such an expenditure, no assurance is at hand that hazard to employes and interference with service will be entirely eliminated, and until more exact knowledge of this whole situation is available, single-phase trolley interference constitutes a most serious handicap to the adoption of any alternating current locomotive system of operation.

Assuming that the favorable results of factory experiments are borne out in the success of later commercial operation, there appear to be no controlling advantages of alternating current locomotive traction which cannot be secured at less expense and with greater reliability in operation with direct current motive power.

Until the adoption of the inter-pole motor construction made it entirely practicable to build direct current motors for high potentials, there was some justification for considering alternating trolley systems as offering the best means of changing from steam to electric motive power at a reasonable first cost. The high voltage direct current motor has now been developed, built and proven completely successful under the most exacting service conditions. The trolley potential has been raised to 2400 volts which seems sufficiently high to ensure a distribution system of reasonable first cost and not too high to handicap the locomotive as regards its first cost, reliability and operating efficiency. Experimental results already obtained with direct current apparatus tested at potentials higher than 2400 volts indicate that no constructive difficulties apparently exist and the installation of a higher voltage becomes an economic question rather than an engineering problem.

With 2400 volts direct current both protected third rail construction and multiple unit car operation are and low cost of maintenance on single track roads and multiple unit car operation is without question the proper way to take care of local traffic. Furthermore, 2400 volt equipments can be successfully operated upon the lower voltage terminal zone that local restrictions may make necessary.

Discussion

George W. Gibbs of New York submitted a written communication in which he stated that until recently practical railroad men have been unable to obtain any clear idea of the possibilities of main line electrification, largely because of the controversial attitude of the conflicting interests involved. Each system has been set forth by its promoters as having all of the virtues and none of the flaws of the other systems and this has raised a doubt in the minds of railroad men as to whether or not any system were entirely satisfactory.

During the last year or two, however, there has appeared to be an inclination on the part of all concerned to admit that the subject is one of many angles and one in which each system has its own particular field of supremacy. He stated, however, that the paper presented seemed to have reverted to the old situation of pleading for some particular system, setting forth as unfavorable as possible the defects of other systems, while the shortcomings of the system advocated were not even referred to.

Mr. Gibbs stated that the author dismissed the single-phase system as unsuitable for main line electrification and based his judgment apparently upon the unsatisfactory results of a number of interurban traction lines that had found it advantageous to abandon the single phase system in favor of direct current. Possibly these trolley roads in question should never have been equipped with the single phase system, but in any event he stated that their case is not comparable with that of heavy steam traction.

He stated that the fact that single phase contact and split phase locomotives were selected for the Norfolk & Western Railway electrification, which is the heaviest electric traction work yet undertaken by any railroad, would tend to discredit the author's summary dismissal of single phase system.

Mr. Gibbs further pointed out that the author's "safe prediction" that, "No more single phase motor equipments will be placed in operation in this country on new roads unless these roads virtually form an extension of existing systems," was rather questionable, particularly in view of the very recent adoption of the single phase motor car system of operation for the Pennsylvania Railroad suburban lines out of Philadelphia.

Mr. Edward Katte, chief engineer of electric traction, New York Central & Hudson River Railroad, also submitted a written communication in which he called attention to the fact that the 800-ton passenger train at 60 miles per hour, considered by the author, was altogether too small to be taken seriously by steam railroad men operating heavy trunk lines at the present time. He stated that the modern electric locomotive must be able to haul a train of cars weighing from 1,000 to 1,200 tons. Electric manufacturers frequently confuse railroad men by including the weight of the locomotive in referring to a train of a given weight. It is customary among railroad men to omit the weight of the locomotive in giving train weights.

He pointed out that an electric locomotive should

be capable of performing in regular service almost continuously and should not require, after a few hours' operation, that it be laid up in the terminal from one to three hours to let the motors cool off. He said that electrical operation is a good thing in the proper place, although it does require a large investment and has certain limitations.

Mr. H. H. Vaughan, Vice President of the Canadian Pacific R. R. in discussing the paper referred to the recent adoption of high tension direct current for a section of that railroad. This installation includes 30 miles of line, 43 miles of track with a long 4 per cent grade, 4 locomotives he said were sufficient to take care of the traffic on this section. He also brought out the point that the battle of systems had had an unhealthy influence on all railroad men in the adoption of electricity of motive power on main line divisions. In the particular division on the Canadian Pacific referred to, he said that the two systems were found to be practically alike, both as to first cost and cost of maintenance. Direct current was chosen, however, because of the fact that the larger part of the investment was involved in cost of copper for feeders rather than in locomotive construction, which might become obsolete in a short time. Moreover, the development of the gearless type locomotive and the improved methods of collecting charge currents from the trolley had a strong influence in the selection of the direct current system.

Mr. W. S. Murray, formerly electrical engineer of the New Haven and at the present consulting engineer in charge of the extension of the electrified zone of that road to New Haven, stated that Mr. Armstrong's paper was the highest card yet played advocating single phase for main line construction and direct current for local and interurban service. He stated that the actual power required to transport a given weight is 22 per cent greater with direct current than with alternating current. The direct current locomotive has many excellent qualities, but one must not ignore other features of the system. He noted the omission by the author of mention of the single phase installation on the Spokane & Inland Equipment Railroad and the New York Westchester & Boston Railroads, on which steam would have been used had not electricity been available.

Manufacture of Ductile Tungsten Wire

The patent entitled "Tungsten and Method of Making the Same for Use as Filaments of Incandescent Electric Lamps and for Other Purposes," which was recently issued to Dr. William D. Coolidge, contains much enlightening information regarding the manufacture of tungsten lamps. The process of manufacture of ductile tungsten wire may be divided into two separate stages, (1) the proposition of an ingot of tungsten, and (2) the working or drawing of that ingot into wire of extremely small diameter.

Commercially pure tungstic oxide is first dissolved in ammonia water, forming ammonium tungstate, this is purified by vaporation and crystallization, washed, dried and then decomposed by moderate heat of about 500 deg. C. which drives off the ammonia and leaves purified tungstic oxide.

This is heated in a gas furnace for several hours in a covered crucible during which process the oxide becomes granulated and apparently absorbs some of the silica and alumina from the crucible. The next operation is performed in a tube of porcelain or fused quartz of about 1.5 in. in diameter and 24 in. long. This tube is packed nearly full of the oxide, excepting for space at each end to allow for entrance of gases. The temperature is gradually raised to about 1,000 deg. C. and pure, dry hydrogen passed through the tube for a period of from six to fifteen hours. During this operation the "yellow oxide" or tungsten is progressively reduced to the blue oxide, then to the brown oxide, and then to the pure metal.

This powdered tungsten is then placed in high hydraulic presses and compressed under great pressure into sticks about ¼ of an in. square and 6 in. long. When removed from the mold this stick of tungsten is gently slid onto a strip of metallic tungsten and placed in an electric furnace at 1,200 deg. C. for approximately half an hour. This heating has the effect of strengthening the stick of tungsten, which, as it is taken from the hydraulic press is very fragile. The stick is then sintered in a closed vessel, ordinarily of copper, containing hydrogen gas; an electric current is passed through the stick which raises the temperature to approximately 2,800 deg. C. An alternating current of approximately 1,800 amperes is employed for about 15 minutes in sintering the stick. When the stick comes from the process it is a solid slug of coherent metal, and this completes the first step in the process of manufacture of ductile tungsten wire.

The stick of tungsten is then heated to about 1,500 deg. C. and passed between the swagging dies very rapidly and receives a slight reduction in area of section and a slight elongation in each pass. This operation is repeated a number of times until the ¼ in. billet is worked into a rod 0.210 in. in diameter. This rod then passes through a series of reductions until its diameter is reduced to 0.060 in., it being kept at approximately 1,300 deg. to 1,700 deg. C. at all times. This is a white heat, but after being drawn down to this diameter, the temperature at which the wire is worked is reduced to a yellow red heat and the wire sized down to 0.030 in. At this stage the wire has become ductile at ordinary room temperature. Further reductions are made at a temperature of between 600 deg. to 650 deg. C. at which the wire is at a red heat and these reductions are made by drawing the wire through diamond dies. In this process the diameter is then reduced 1-mil drafts, to 0.014 in.; then, by 0.5-mil drafts, to 0.0055 in.; next by 0.25-mil drafts, to 0.004 in.; then by 0.2-mil drafts to 0.002 in.; by 0.1-mil drafts to 0.0014 in., and finally by 0.05-mil drafts to a diameter of only 0.0005 in., or 0.5 mil.

The inventor states that the tungsten wire thus produced has a different metallic texture and different properties from any other form of tungsten heretofore obtained, in that it is of a fibrous structure instead of crystaline The tensile strength is exceedingly high. Certain samples of 0.001 in. diameter have shown a strength of from 600,000 lbs. to 650,000 lbs. per square inch. He states that these properties are largely due to the special heat treatment given the tungsten.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

Lesson No. 9--Magnetism

All back lessons of Course can be furnished.

11. Forms of Magnets.

A bar magnet, such as is mentioned in the preceding paragraphs, can be bent so that both of its poles point in the same direction, as shown in Figure 7, which also shows approximately the distribution of the magnetic field or lines of force. A magnet of this form is called a horseshoe magnet.

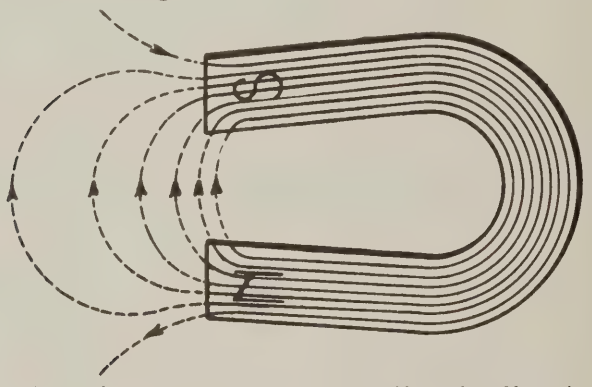


Fig. 7—Showing Magnetic Field of a Horseshoe Magnet

Both of its poles can be brought to bear on the same object, and horseshoe magnets will therefore lift heavier weights than bar magnets of similar proportions. Another characteristic of horseshoe magnets is that they retain their strength better than bar magnets. This appears to be due to the fact that the air gap, or distance the magnetic lines of force must pass through air before the poles, is shorter. Magnets of the horseshoe type are very often used in electrical measuring instruments, such as direct current voltmeters and ammeters.

The ordinary horseshoe magnet is usually provided with an armature or keeper, which helps to preserve the strength of the magnet.

12. Residual Magnetism—Retentivity.

Any piece of magnetic material brought in contact with a magnet, or within a magnetic field, becomes a magnet itself. Suppose that three bars of the same size are prepared, one of soft iron, one of soft steel and one of hard steel, and that one end of each bar is dipped into iron filings while a strong magnet is brought in contact with the other end. When the bars are withdrawn and the magnet removed, the most filings will adhere to the hard steel, less to the soft steel and very few to the soft iron. The filings are held by the residual magnetism of the bars, and the ability to retain magnetism is called retentivity. This would indicate that hard steel has greater retentivity than either soft iron of steel.

13. Ageing.

In order that magnets used for certain purposes may be satisfactory, it is important that their strength remain constant. After magnetization it is found that the strength of even the hardest steel magnets decreases for some time, especially if they are subject to severe changes of temperature or to mechanical vibration or shock. However, a point is finally reached where the residual magnetism is really permanent, and the strength of the magnet does not diminish. In order that this point of permanent strength may be reached quickly, magnets are often put through a process called ageing. This process consists in subjecting the magnets to repeated changes of temperature and mechanical jars and shocks, until tests show that their strength has fallen to a constant value. Well aged magnets of the best magnet steel will remain practically constant indefinitely.

14. The Earth's Magnetism.

Everyone knows that a compass needle is a magnet, and that it takes a definite position when free to swing, pointing nearly north and south. From preceding paragraphs, it is evident that the compass needle must be acted upon by a magnet whose lines of force run north and south. This magnet is the earth itself. If a bar magnet, about half the length of the earth's diameter, were thrust through the earth's center, making an angle of about twenty degrees with its axis, it would account for many of the phenomena of terrestrial magnetism.

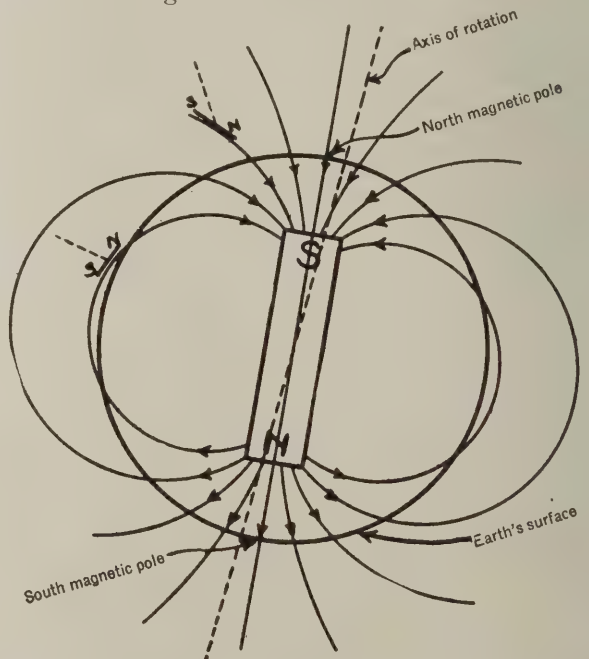


Fig. 8—Showing the Distribution of the Earth's Magnetism

The south pole of the magnet would be at the end under the northern portion of the earth's surface. The lines of the earth's magnetic force are only parallel with the earth's surface at certain places near the equator, as can be seen by reference to Figure 8. In the northern hemisphere the compass needle tends to dip its "N" pole downward, in order to parallel the lines of magnetic force, while in the southern hemisphere the "S" pole has a similar tendency. Directly over the magnetic poles of the earth, the compass

needle, if free to turn in all directions, would point directly downward.

15. Declination.

Owing to the fact that the magnetic poles do not coincide with the geographical poles of the earth, the compass needle does not point true north at most places on the earth's surface. The angle between the magnetic north and south line or meridian, and the geographic north and south line or meridian, at any point, is the declination of the earth's magnetic field at that place.

16. Inclination.

Paragraph 14 and Figure 8 show that the earth's lines of force are not horizontal at most places on the surface. A compass needle mounted to swing vertically (on a horizontal axle) is called a dipping needle. When set to swing in a magnetic north and south line, the needle will assume a position parallel to the earth's magnetic field. The angle which the needle makes with a horizontal surface is the inclination of the earth's field.

At the present time (1913), the declination at Philadelphia is about seven degrees west, and the inclination about seventy degrees. In other words, the compass needle points seven degrees west of true geographical north, and the dipping needle has its north pole downward, and makes an angle of seventy degrees with the horizontal.

17. Theory of Magnetism.

There have been a number of theories advanced to account for magnetic phenomena, but the one commonly accepted at the present time is the molecular theory. All the forms of material are considered to be made up of very small particles which are called molecules. It is supposed that each particle or molecule of iron or steel (magnetic materials) is naturally a magnet, with a north and south pole. In an unmagnetized bar the poles of molecules are turned in all directions, so that the fields of force of the different molecules neutralize each other, and the bar as a whole shows no magnetic qualities. In paragraph 6 it was stated that a magnet, when placed in a magnetic field, tends to turn until it is parallel to the lines of force. Therefore, if the bar under consideration is placed in the field of a magnet, the molecules all try to turn parallel to the lines of the field. When the molecules are turned in the same direction their magnetic fields act together, and the bar, as a whole, becomes a magnet.

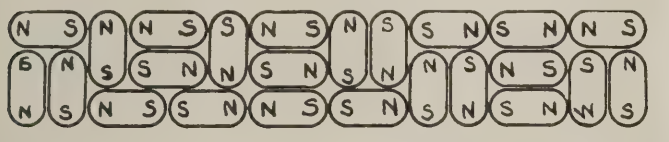


Fig. 9—Illustrating the Relation of Molecules in a Bar which is Not Magnetized

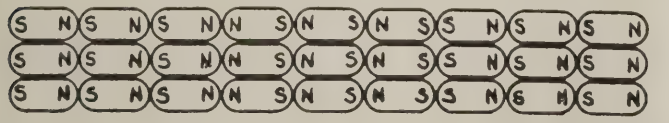


Fig. 10—Showing Arrangement of Molecules in a Magnetized Bar

The condition of the molecules of the unmagnetized bar is represented by Figure 9a, and the condition of the magnetized bar by Figure 9b. In this figure, the very minute particles or molecules which form the magnet are shown rather large and are marked on their ends "N" and "S." In reality, a molecule cannot be seen by the naked eye, as it is too small, but can be seen with the aid of powerful microscopes.

The properties and behavior of magnets are more readily understood through a study of this molecular theory.

18. Strength of Magnets.

It is well known that all magnets of the same size and shape are not of the same strength. It can readily be seen that the greater the number of molecules turned to act together magnetically the stronger will be the magnet.

19. Permeability.

A bar of soft iron subjected to magnetic force will become a stronger magnet than a similar bar of hardened steel subjected to the same force. This is because the molecules of the iron bar offer less resistance to turning than those of the steel bar, and therefore, more of them are "lined up" by the magnetizing force. This difference is expressed by saying that the permeability of the iron is greater than that of the steel.

In paragraph 12, retentivity was illustrated and defined. Evidently, if the molecules of a material are diffcult to turn in magnetizing a bar, these same molecules will tend to remain in the magnetized position after the force is withdrawn, so that a material which has low permeability, or which is difficult to magnetize, will have high retentivity or will retain its magnetism well.

20. Demagnetization.

Any magnet heated to a red heat loses its magnetism, and does not regain it when cooled off again. Iron and steel at high temperatures are non-magnetic, and cannot be magnetized or attracted by a magnet. It is believed that the action of high temperatures sets the molecules of the metal in vibration and thus breaks up magnetic combinations that exist and prevents others from forming. Another method of demagnetization is to place the object to be demagnetized in a strong magnetic field, which is then reversed in direction many times and at the same time gradually reducing to zero strength.

21. Saturation.

If the magnetizing force acting on a bar is great enough, it is reasonable to suppose that all the molecules will be turned in one direction, and that the bar will be fully magnetized. In this case the bar is said to have reached magnetic saturation. No increase in the magnetizing force, however great, will increase the magnetic strength of the bar after this saturation is reached.

22. Equality of North and South Polarity Magnetism.

Each molecule of magnetic material is supposed to be a magnet with north and south poles of equal strength. Therefore, when the material is magnetized, and the molecular magnets are turned to act together, the number of north poles acting together will be the same as the number of south poles combining forces and the total positive and total negative magnetism produced will be equal.

23. Magnetic Circuit.

The equality of north and south polarity magnetism may be stated in another way, by considering that the lines of force form a magnetic circuit, as briefly stated in paragraph 6. In any magnetic circuit, the total number of lines of force issuing from the north poles is the same as the number of lines entering at the associated south poles.

24. Divided Magnets.

If a bar magnet is broken in two pieces, each piece

will be a magnet. A consideration of Figure 9b, will show why this is the case. Since each of the smallest particles is a magnet, it is evident that every combination of these particles is also a magnet, as long as the molecules are turned in the same direction.

25. Consonant Poles.

If two bar magnets are placed end to end, with their south poles together, the field produced will be like that of one magnet with a north pole at each end and a south pole of twice the strength at the center.

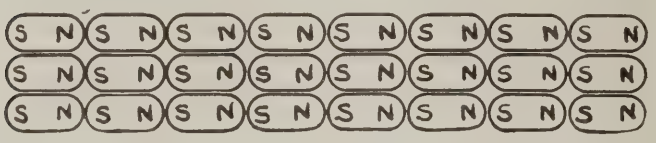


Fig. 11—Illustrating the Arrangement of Consequent Poles

By proper application of the magnetizing force, a single bar may be so treated that it will have poles at other points in addition to those at the ends. These intermediate poles are termed consequent poles. The arrangement of the molecules in a magnet with consequent poles may be imagined to be similar to that shown in Figure 10.

26. Action Between Magnets.

The force of attraction or repulsion between two magnet poles is inversely proportional to the square of the distance between them. This relation may be expressed in the following formula:

$$\frac{F}{F_1} = \frac{r_1^2}{r^2} \text{ or } F : F_1 : : r_1^2 : r^2 \qquad \text{eq. (1).}$$

in which F is the force attraction at a distance r between the poles and F_1 is the force attraction of the same two magnet poles at the distance r_1 between them. From eq. (1), the product of the force and the square of their distance apart is the same for any distance between the poles.

For example, when two magnets are held one inch apart and they repel each other with a force of ten pounds, the push between them when held at a distance of two inches would be found by applying formula 1, substituting these values: $F = 10$, $r = 1$, $r_1 = 2$; then

$$10 : F_1 : : 2^2 : 1^2$$

from which $F_1 \times \frac{10 \times 1^2}{2^2} = 2.5 =$ number of pounds push at a distance of two inches. If the distance between these poles had been ½ inch, then the repulsion would be found by this same formula as

$$10 : F_1 : : (\tfrac{1}{2})^2 : 1^2$$

from which $F_1 = \frac{10 \times 1^2}{(\frac{1}{2})^2} = \frac{10}{\frac{1}{4}} = 40 =$ number of pounds push at this shorter distance.

The problems would be worked the same if the poles were unlike. The force exerted would then be a pull or force of attraction instead of a push or repulsion.

27. Commercial Applications or Permanent Magnets.

Perhaps the most important use of permanent magnets is in the mariner's compass, although the magnets used in these instruments are very small. Permanent magnets of various forms are also used in telephone receivers, telephone magnetos or ringing generators, magnetos for gas engine ignition, electrical measuring instruments, etc. In future pamphlets the use of magnets for most of these purposes will be explained.

Second Lesson.

11.—What is the inclination of the earth's magnetic field at the south magnetic pole? Which end of the dipping needle would point below the horizontal?

12.—Will a material having great retentivity have high permeability? Give a reason for your answer.

13.—(*a*) How would you demagnetize a bar of steel?
(*b*) How can a watch be demagnetized?

14.—Is there any limit to the strength that can be given to a magnet? Explain your answer.

15.—A bar magnet eighteen inches long is broken into three pieces six inches long. Will any of these pieces be magnets? If so, which ones?

16.—How many magnetic poles would there be in the bar in Figure 10? Make a sketch showing their location and polarity.

17.—How does the distance between two magnet poles affect the attraction or repulsion (pull or push) between them?

18.—Two magnets are held one inch apart, and the pull between them is one pound.
(*a*) What will the pull amount to when they are six inches apart?
(*b*) When they are one-eighth of an inch apart?

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

The January meeting of the Railroad Electricians' Club was attended by about 70 men and apparently every one there, even the fellow that did the talking, seemed to derive a great deal of pleasure and benefit from the meeting.

Any of you fellows who live near Chicago and don't attend these meetings, are passing up a great opportunity for developing yourself and getting posted in the theory of electrical apparatus—come around to the meeting and see for yourselves. Some of the boys come over a hundred miles to attend these meetings.

After a brief discussion on primary cells and condensers, given in Lessons No. 3 and No. 4, we took up the problems of the Pennsylvania course as given herewith:

Problems

Eighth Lesson.

Question 45. What do you use to make up a gravity cell, and just how are these things put together?

Ans. 45. Clean the old jar thoroughly and put a copper plate at the bottom, add about 3 pounds of blue vitrol crystals which are free from dirt and other impurities, and of size not smaller than a pea and not larger than a hen's egg. Place the zinc plate in position and pour in pure water containing no iron or other impurities (rain water is usually satisfactory). The level of the water should come somewhat above the zinc and, in order to make the solution conduct well at the start, add either a little sulphuric acid or some of the clear

(zinc sulphate) solution from the top of a cell already in service. If neither of these are available, the cell should be short circuited for about two days, in order to form the zinc sulphate solution at the top of the cell and incidentally reduce the internal resistance of the cell. Be sure to spread the copper plate out well when first put in place.

Question 46. What is the voltage of a gravity cell?

Ans. No. 46. When in good condition the gravity cell will generate about one volt and will easily give a continuous output of ¼ of an ampere.

Question 47. Why is it always used on closed circuit?

Ans. No. 47. It is always used on closed circuit in order to keep the two solutions which make up the cell separate. If allowed to stand on open circuit for any length of time the blue solution in the bottom of the cell diffuses upward and contaminates the clear zinc sulphate solution on the top.

Question 48. What happens if the blue solution gets to the top of the cell? What causes this to happen, and what should be done when it does occur?

Ans. No. 48. The electro chemical action of the current flowing through the cell prevents the blue copper solution in the bottom from getting to the top of the cell. In other words, the current continually deposits copper on the lower electrode and the zinc pole is eaten away by the current, forming zinc sulphate. There is a continual tendency of the blue copper solution to diffuse upward but this is overcome by the action of the current. If the circuit is broken, however, and the battery allowed to stand on open circuit very long, the copper sulphate solution soon diffuses to the top of the cell.

It is a well known fact that if a piece of zinc or iron is inserted for an instant in a pure copper sulphate solution, the zinc will be attacked just as strongly as if it were dropped in sulphuric acid; and the copper, formerly in solution as copper sulphate, is deposited upon the zinc or iron plate.

Applying this knowledge to primary batteries: as soon as the copper solution gets to the top of the cell, spots of metallic copper are deposited on the zinc plate. As soon as this occurs you create a new copper pole in the battery which is in direct metallic connection with the zinc pole, in other words, short circuited. So there will be a continuous flow of current from the unspotted parts of the zinc plate or crowfoot, to these copper spots. Unless this is immediately remedied it will cause the zinc plate to be rapidly eaten away. When this occurs, remove the zinc plate and put in a new one; meanwhile, being sure that there is no copper solution at the top of the cell to contaminate the new plate. The old crowfoot can be cleaned by scraping and dipping it a few times into a strong nitric acid solution; this will eat off the copper and also some of the zinc. When the crowfoot is thoroughly rinsed it is ready for business.

Question 49. Why is it necessary to place a rubber tube over the wire leading down to the positive copper plate in the bottom of the cell?

Ans. No. 49. This is to prevent the copper wire coming in contact with the zinc plate, which would cause a short circuit; it also prevents chemical action on the wire at the surface of the liquid and further prevents the deposit of copper on the wire which might tree across to the zinc plate and short circuit cell.

Question 50. Is a dry cell actually dry?

Ans. No. 50. No. The electrolyte of a dry cell is a moist paste consisting usually of salammoniac with a depolarizing powder. If the cell really becomes dry, due to a leak in the jar, it will give no voltage as no current can flow through the dry powder.

Question 51. What is the voltage of a dry cell?

Ans. No. 51. The voltage of a dry cell varies from 1.3 volts to 1.6 volts, depending upon the condition and type of the cell.

Question 52. What is the difference between a dry cell and a gravity cell.

Ans. No. 52. A dry cell is composed of a carbon positive plate and zinc negative, with a salammoniac paste for the electrolyte, while a gravity cell has a copper positive plate and a zinc negative, with an electrolyte of copper sulphate around the copper plate and zinc sulphate around the zinc plate.

Ninth Lesson.

Question 53. Can a dry cell be used on closed circuit?

Ans. No. 53. A dry cell cannot be used on closed circuit because its voltage rapidly falls off as current flows through the cell.

Question 54. Suppose you connect a condenser of 1 m.f. to a battery of 20 volts, then remove the condenser and connect it to a voltmeter, the electricity stored in condenser will discharge through the voltmeter, giving the needle a "kick" to, say 8 scale divisions, what is the capacity of another condenser which when connected with the same battery gives the voltmeter needle a kick of 16 scale divisions?

Ans. No. 54. If the second condenser gave twice as heavy a "kick" when charged to the same voltage as the 1 m. f. condenser, it must have twice the capacity, or 2 m. f.

Question 55. Supposing a condenser is discharged by allowing it to spark, is this current simply a direct current flow, or is it an alternating current flow?

Ans. No. 55. The spark from a condenser is not simply a direct flow of current such as we get when short circuiting a battery, but consists of a series of very rapid oscillations of current, beginning at a high value, depending upon the voltage to which the condenser is charged, its capacity, etc. This current quickly comes to zero, taking but a small fraction of a second to discharge.

The larger the condenser the slower will the oscillations of current be and, of course, the current flow will be heavier. You can consider a condenser acting very much like a drum head, and the discharge of the condenser is like striking the drum a blow. The larger drum will vibrate slower and more powerfully, and the small drum will vibrate more rapidly and with less force.

Question 56. If 2 condensers, each of 2 m.f. capacity, are connected in series, what is the capacity of the combination?

Ans. No. 56. In finding the joint capacity of two condensers connected in parallel we simply add the individual capacities of each condenser (note the difference from the way resistance is figured), and with two condensers in series the joint capacity is not the sum of the two capacities, as would be the case in figuring resistance, but is found as follows: Take the reciprocal (inverted fraction) of each of the capacities, add these reciprocals and take the reciprocal of the sum. The reciprocal of each 2 m. f. capacity is ½ and adding ½ plus ½ gives us 1, and the reciprocal of 1 (inverted fraction) is 1. Therefore, the joint capacity of these two condensers of 2 m. f. each capacity in series is 1 m. f.

Question 57. If 2 condensers of 2 m.f. capacity, are connected in parallel, what is the capacity of the combination?

Ans. No. 57. Where two condensers are connected in parallel, the joint capacity of the combination is the sum of the individual capacities. Therefore, the capacity of this combination would be 2 m. f. plus 2 m. f., or 4 m. f. total capacity.

Question 58. Suppose you wanted to get a total capacity of just 7 m.f. and had nothing but condensers of 2 m.f. available how could you connect some of these up to get the required 7 m.f. capacity?

Ans. No. 58. As we have seen from answer 56, if two condensers of 2 m. f. capacity each are connected in series, the resulting capacity is 1 m. f. By connecting three 2 m. f. condensers in parallel we get a total capacity of 6 m. f. and by connecting the series combination above mentioned in parallel with these three, we get the additional 1 m. f. capacity, making a total of 7 m. f. capacity desired.

Tenth Lesson.

Question 59. How do you test a dry cell to see if it is any good?

Ans. No. 59. As in storage battery work the open circuit voltage of a dry cell means little or nothing, for a cell that is down and out may give a high open circuit voltage. Therefore, in order to find out the true condition of the cell we must test it for current rather than voltage. Dry cells are made in different capacities, some giving as high as 25 amperes when short circuiting through an ammeter. The average dry cell, however, should give about 20 amperes when new and in good condition.

Question 60. Why are dry cells used in door bell and telephone work instead of gravity cells?

Ans. No. 60. In door-bell and telephone work the battery is only used occasionally and there may be periods of days and even weeks in which it is not used at all. Therefore, this service is necessarily an open circuit proposition.

Dry cells do not deteriorate on open circuit, but as we have learned from problems No. 45 to 50, the gravity cell is soon destroyed if left on open circuit.

Question 61. What is meant by polarization? Does this occur in a gravity cell or in the Edison and Gordon cells?

Ans. No. 61. By polarization we mean the reduction in the voltage of the cell, due to the collection of gases on the plates decomposed by the electro-chemical action of the current. When current is drawn from a dry cell hydrogen gas soon collects around the carbon plate. Various oxidizing agents are employed, such as manganese dioxide, which gives off oygen which combines with the hydrogen, forming water and preventing the collection of hydrogen gas at the carbon plate, which causes polarization. This, however, does not entirely eliminate the difficulty and the voltage of a dry cell soon falls if a strong current is taken from the cell.

This polarizing action does not occur in the gravity cell, for the reason that instead of liberating gases, the electro chemical action at the positive and negative pole is such that zinc is eaten away from the negative pole and copper deposited on the positive pole. In the Edison and Gordon cells the depolarizing action is neutralized by the copper oxide in the positive plate.

Question 62. Can you renew a dry cell?

Ans. No. 62. Very often a dry cell can be temporarily rejuvenated by soaking it in water. The chemical action within the battery as it discharges eats away the zinc jar, and often eats holes all the way through so that the interior of the cell is allowed to dry out.

Don't try to solder up the holes, for lead solder will act just the same as copper on the zinc plate of a gravity cell, as described above. Dry cells are so cheap that it does not pay to try to repair them except in the case of temporary necessity.

Question 63. How is the Edison cell made, and what is its voltage?

Ans. No. 63. The Edison Lalande cell consists of copper and zinc electrodes in an electrolyte of caustic soda. The copper oxide electrode is plated with a thin film of metallic copper to reduce the resistance of the cell when it is first started. The voltage of the cell is .78 of a volt at the start but after working for a time it decreases somewhat.

Question 64. If it takes 250 milli amperes to work a 300 ohm relay on a telegraph circuit 25 miles long, consisting of a No. 10 N. B. S. galvanized iron wire of the B. B. grade (see table No. 5, June lesson), how many gravity cells must be connected in series to force the 250 milli amperes required to work the relay through both the line resistance and resistance of the relay?

Ans. No. 64. The first step in this problem is to find the total resistance of the line. From table No. 5 we find that a No. 10 wire of the B. B. grade has a resistance of 22.48 ohms per mile. This multiplied by the length of the line (22.48x25) gives a total of 562 ohms for the resistance of the line. This when added to the 300 ohm relay makes a total line resistance of 862 ohms. Two hundred and fifty milli-amperes equal ¼ of an ampere, so the problem is to find what voltage will be required to force ¼ of an ampere through 862 ohms resistance. Since, as we learn from Lesson No. 1, the voltage of a circuit is equal to the current times the resistance, the voltage in this case is (¼ times 862 or) 216 volts.

Since the voltage of a gravity cell is approximately one volt, it will require 216 cells for this circuit.

Question 65. How many gravity cells must be used if there are six stations on the line having a 300 ohm relay in each?

Ans. No. 65. If there are 6 stations on the line with a 100-ohm relay in each, the total resistance of the circuit will be the resistance of the line, 562 ohms, plus the resistance of the relays (600 ohms) or a total of 1162 ohms. If it takes 250 milli-amperes to work these relays, the problem is then to find what voltage will be required to force ¼ of an ampere through 1162 ohms. As in problem above, the voltage is equal to the current, times resistance (1162x¼) or 290 volts. This will require 290 gravity cells.

After working out the problems we passed around the "Question Box" and drew the following questions:

Problems for Next Month

(See lesson No. 4, Sept., 1913)

3rd Lesson, Primary Batteries.

Ques. No. 66. Supposing one of the gravity cells in the battery goes bad and the only thing you have to replace it with is a Gordon cell, what plate of the Gordon cell would you connect in place of the zinc plate of the gravity cell?

Ques. No. 67. Which plate would you connect of an Edison cell in place of the zinc of the gravity cell?

Ques. No. 68. Supposing it was necessary to replace one dry cell in a battery of cells with an Edison or a Gordon cell, what plate would you connect in place of the zinc plate of the dry cell?

Ques. No. 69. Why are not gravity cells used in signal work or outside telephone or telegraph work or any other electrical devices exposed to cold weather in the winter time?

Ques. No. 70. Under what conditions would it be necessary to connect Gordon cells in parallel, and what conditions for the Edison cell?

Ques. No. 71. We have a certain battery consisting of 20 cells connected in series of a rated capacity of 200 ampere hours. The voltage available from each cell is .75 of a volt, the external resistance of each cell is .005 ohms and there is an external resistance of 100 ohms in the circuit. This circuit is closed 10 hours each day, how long will the battery last under these conditions, assuming it was new and in first-class condition at the start?

Fourth Lesson.

Ques. No. 72. We have another circuit having 16 cells in series of a rated capacity of 400 ampere hours connected with a resistance of 75 ohms. The voltage per cell and the re-

sistance of the cells are the same as in problem 71 and the circuit is closed approximately 4 hours per day. How long will the battery last?

Ques. No. 74. Suppose that it is desired to renew a certain battery installation once every six months and that in order to be as economical as possible, we will use the smallest size battery suitable for the work. The circuit requires 3 amperes at 6 volts and operates approximately 2 hours per day. If the cells used are capable of furnishing current at .65 of a volt per cell, (A) what number of cells should be connected in series, (B) what capacity in ampere hours per cell would be advisable to install, (C) how should they be connected, (D) show sketch of connections which should be made.

Fifth Lesson.

Ques. No. 75. If 10 Edison B. S. C. O. cells of a 250 ampere hour rating are connected in series and discharged at the rate of .3 of an ampere continuously, how long will the cells last?

Ques. No. 76. Supposing the cells of problem No. 75 had been connected, 5 sets of 2 cells each, in multiple, giving a total voltage of 5 volts instead of 10 volts as in the preceding problem and the discharge current assumed as the same, .3 of an ampere continuously, how long will the battery last? Show sketch of the connections.

Ques. No. 77. Just what is the difference between 4 cells connected in series and the same cells be connected in multiple? Show sketch. If each cell generates a potential of 1 volt, what is the potential delivered to the external circuit in each case?

Ques. No. 78. What is the difference between series multiple and multiple series connection for batteries. If each cell generates a potential of 1 volt, what is the potential delivered to the external circuit, assuming a total of 30 cells connected, 5 in series and 6 in series multiple in each case?

Ques. No. 79. If the 30 cells of problem 78 each have a capacity of 250 ampere hours and the external resistance of the circuit is 20 ohms, and the batteries are operated in continuous service, how long will they last if connected in series parallel combination, and how long in the parallel series combination?

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 25
Control of Battery Charging

There is probably no service in which storage batteries are operated in which the conditions are more uncertain and more difficult of proper control than that of axle car lighting. So this course of lessons could not be considered complete without a very serious consideration of this important subject of controlling the charge which the storage battery receives.

A certain amount of personal attention is absolutely essential to the successful operation of any storage battery, but in car lighting work, on account of the fact that the apparatus operates only when on the road and must go for days often without any attention whatever, it becomes necessary to depend upon the operation of automatic apparatus for controlling the charge.

There are today a large number of axle equipments employing the original constant current method of control, in fact, one large railroad of the west, operating over 700 axle equipments, prefers the constant current method of regulation to any of the voltage devices of more recent manufacture, adjusting the current regulator, according to the requirements of the run in which the car is operated and the time of year. It will undoubtedly surprise many of us to learn of the great variation in setting of the regulator made necessary simply by the increase of the hours of lighting in the winter time and the decrease in the hours of day charge as described later in this lesson.

There are four ways of controlling the battery charge in an axle equipment which must be considered:

(1) adjustment of current regulator to suit the requirements of the service.

(2) regulator set at maximum and voltage relay employed for stopping the charge when the battery voltage rises to a certain point.

(3) combination voltage-current regulator, as employed in most of the recent axle devices for automatically tapering the charge when the battery voltage rises to a certain point.

(4) the ampere hour meter for automatically stopping the charge when the proper amount of charge in ampere hours has been put into the battery.

Adjustment of Current Regulators

There is no definite rule by which the adjustment of any current regulator may be made as it varies with each type of regulation, that is, as to whether it is a total generator current regulator, a battery current regulator, or a combination of the two, and it also depends upon the class of service, hours of run, time of the year, etc., as will be seen from the accompanying diagrams.

In general, however, it may be said that the regulator should be set so that the aggregate ampere hours charge of the battery during the entire run, both day and night, should be about twice as great as the average ampere hours discharge at the slows and stops during the night. It should be noted, however, that the batteries are discharged whenever the train is running below critical speed (about 15 miles per hour). In figuring the total number of ampere hours discharge, the hours of run at slow speed in yards, or on mountain grades must be included.

It is easy enough to adjust a current regulator so that it gives sufficient charge to the battery for if it does not, the fact is soon indicated by a light failure. But to set the regulator at approximately the correct value, so as to provide sufficient charge, yet not badly overcharge the battery, is a far different proposition. A battery may be badly overcharged on the road and become practically ruined before the situation would be indicated by a light failure. In the accompanying diagrams we show the hours of lighting and the hours of charging for a diner, a coach on an overland run and a Pullman car. These illustrate 3 distinct classes of service.

Overland Run.

Assume we have a coach on an overland run consuming 20 amperes lamp current. Of the 24 hours run each day we find from traffic and speed records

that the train is traveling above critical speed, only 18 hours per day. From the accompanying diagram, Fig. —, which shows the hours of lighting during the various months of the year, we find that during June the lamps will be lighted only 10 hours, while in December they will be on over 17 hours. Since the generator operates only 18 hours a day, in June, the lamps will be turned on for 7½ of the 18 hours and there will be 10½ hours charge without lamps, in January, however, we find that of the 18 hours generator operation, the lamps will be on for 12¾ hours and there will be only a 5¼ hour charge without lamps.

Since the generator is below critical speed and the equipment not operating for 6 hours per day, the lamps will be on the battery (6-24 of 10 hours, or) 2½ hours during June and (6-24 of 17 hours, or) 4¼ hours.

This daily discharge of 2½ hours in the summer time at 20 amperes would amount to approximately 50 ampere hours and in the winter time 85 ampere hours, showing that the discharge is almost double in the winter time to what it is in the summer time.

In order to make up for battery losses and to provide for emergencies, we must figure on a charge of about double the discharge. This in the summer time would then require 100 ampere hours charge and in December 170 ampere hours charge each day. In June we find there are 10½ hours available for charge without lights so if we assume that this whole charge is put into the battery during these 10 hours it would require that the regulator be set at 10 amperes. This, however, is far below the lamp consumption, so if the regulator was set at this low value there would be a continual discharge of 10 amperes all the time the equipment was running at night. If the regulator is set at 20 amperes, so as to just furnish current for the lamps at night, it is seen that during the 10½ hours day charge there would be 210 ampere hours put into the battery. As only 100 ampere hours charge is required in June, this will be far too high a setting, so the correct setting for that month will be something between these two values of 10 and 20 amperes. It is found, by trying different settings and figuring the day charge which will be sufficient to make up for the night discharge at stops and also night discharge while running, that the correct value of the setting is 15.6 amperes for June.

In the accompanying table is shown the settings of the regulator at various months of the year necessary to provide a battery charge of twice the average discharge. This will be sufficient to make up for battery losses and emergencies of service.

As mentioned above, this table is based upon a coach consuming 20 amperes lamp current and operating on an overland 24 hour run. This table is given only as a rough guide. It must be remembered that the regulator setting must be calculated to meet the conditions of each particular run, the discharge and the percentage of time below cutting in speed will vary on different roads and even on different trains.

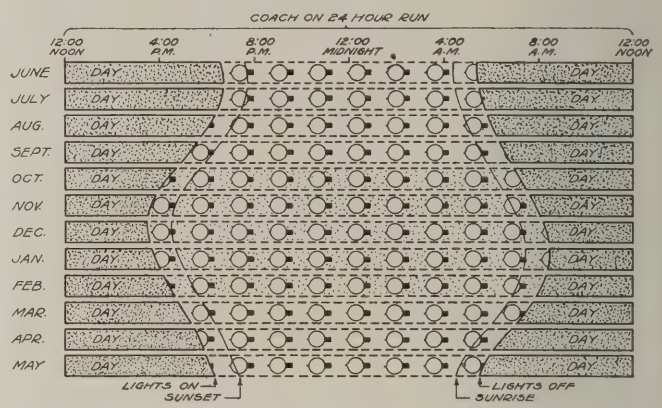


Fig. 136—Hours of Lighting and Charge for Various Months of the Year for a Coach on Overland Run. The Dots Indicate Charging. Note That Batteries Are Charged at Night Some Months and Not Charged Others

This table shows that the regulator setting should be varied from 15.6 amperes in June, to 23.7 amperes in December or, roughly, from 16 to 24 amperes. In applying this table to practical service it is, of course, impossible to adjust every regulator every month, but this should be done four times a year, as follows: August 1st, 20 amperes; November 1st, 24 amperes; February 1st, 21 amperes; May 1st, 17 amperes.

If the regulator is set high enough to provide sufficient charge all year round so that it need not be reset, there will be an overcharge of (8x10½ or) 85 ampere hours every day in June and July. This is assuming that the setting is just high enough to cover January conditions. Where this setting is made from a rough guess as to conditions, it will be usually higher than necessary, so the overcharge would be something greater than this.

Dining Car Service.

Conditions of operation in dining car service vary widely, but as a general thing are unusually severe; that is, in the winter months practically the entire

TABLE FOR COMPUTING REGULATOR SETTING.

	Hours Lighting	Hrs. Day Chge.	Night Dischge. at stations in amp. hrs. + 100%	Reg. Setting	Chge. or Dischge. en route at night		Hrs. Night Operation	Night Dischg. en route Amp. hrs. + 100%	Total Discharge	Day Chge.	Night Charge	Total Charge
June	10	10½	100	**15.6**	4.4	Amp. discharge	7.5	.66	166	164	..	...
July	11	9.8	110	**16.7**	3.3	Amp. discharge	8.2	.54	164	164	..	...
August	12	9.0	120	**17.8**	2.2	Amp. discharge	9.0	.40	160	161	..	...
September	13.2	8.1	132	**18.8**	1.2	Amp. discharge	9.9	.24	152	152	..	...
October	15.0	6.7	150	**20.5**	0.5	Amp. charge...	11.2	..	150	139	11	150
November	16.2	5.8	162	**22.6**	2.6	Amp. charge...	12.1	..	...	131	31	162
December	17	5.2	170	**23.7**	3.7	Amp. charge...	12.8	..	...	125	47	...
January	16.5	5.6	165	**23.0**	3.0	Amp. charge...	12.4	..	...	129	37	166
February	15.5	6.4	155	**21.6**	1.6	Amp. charge...	11.6	..	155	138	18	156
March	14.2	7.4	142	**19.8**	0.2	Amp. discharge	10.7	.4	146	146	..	...
April	12.5	8.6	125	**18.3**	1.7	Amp. discharge	9.4	.32	157	157	..	...
May	11.2	9.6	112	**17.0**	3.0	Amp. discharge	8.4	.50	162	163	..	...

run is made with all lights on and there is sometimes a discharge in the winter time of almost an hour in receiving at the station, stocking up in the yards, etc. On the other hand, during the summer months almost the entire run is made under daylight conditions and the yard and station discharge is largely eliminated.

Upon referring to the diagram Fig. 137, the variation in the hours of lighting for the different months is clearly seen. The dots indicate charge and it will

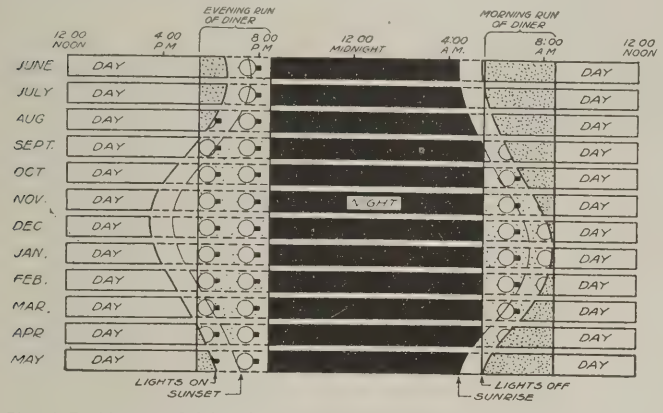


Fig. 137—Hours of Lighting and Charge at Various Months of the Year for a Diner. Dots Indicate a Charge

be noticed that during the summer months there is no charge when the lamps are on, but in the winter months the regulator setting has been raised above the lamp discharge, so the battery will be on charge whenever the equipment is operating.

From the operation of a certain diner running from 5:30 to 8:00 every evening and 5:30 to 8:00 every morning, as shown in diagram Fig. 137, it is found that this generator operates 5 hours of the 6 hours total run, the lamp discharge of the car is 40 amperes at 30 volts. It is found that the discharge in the yards and at stations amounts to a total of 30 minutes in June and approximately 2 hours in January. This discharge amounting to 20 ampere hours in June and 80 ampere hours in January, would require a charge approximately 50 per cent greater, or 30 ampere hours in June and 120 ampere hours in January (The charge is taken at 50 per cent greater in this case because a large part of the discharge occurs in the yards where conditions can be governed.)

Since the lights are on for the entire trip during the winter months there will be no charge without lights therefore, the regulator setting must be the sum of 40 amperes lamp current, and (120 divided by 5, or) 24 amperes battery charge, a total of 64 amperes in January. It will be found that in April if the regulator setting is reduced to the lamp load of 40 amperes, the day charge of 1.8 hrs. will just about provide sufficient battery charge. During the summer months, however, the lighting hours decrease and the charging hours increase rapidly. It is found that in June a regulator setting of 22 amperes will provide sufficient charge for the battery during the 3½ hours charge with no lights to make up for the 30 ampere hours discharge in yards and stations plus the continual discharge of 18 amperes, (the difference between 22 and 40), while the generator is operating.

This shows the wide variation between winter and summer operation in dining car service. In order to have anything like a correct setting of the regulator it should be adjusted at least 4 times a year and preferably every 2 months. On the 3 months period basis the regulator should be set: February, at 50 amperes; May, 35 amperes; August, 50 amperes and November, 65 amperes. Even on this basis there will be an overcharge of over 60 ampere hours in the day at certain times of the year.

Pullman Car Service.

Insofar as setting the regulator is concerned, Pullman cars having a night run only, are less troublesome than diners or cars on a run which is part night and part day. In many cases it is found, however, that there is a long discharge every night while receiving in the station, which is sometimes a rather severe drain on the storage battery.

It will be noted from referring to the diagram Fig. 138, that we do not have the great variation in number of hours for lighting and charge that we have in either of the other cases. This particular car has an average full load lamp current of 40 amperes at 30 volts. Lights are turned on at 9:00 and the train leaves at 12:00, most of the lights being turned out at 1:00, the night circuit alone remaining. In the winter months, however, all lights are turned on at 6:00 in the morning and, during December, January and February, remain on until the end of the run at 8 A. M. Assuming that the generator is below operating speed about ¼ of the total run, we will have a total discharge of approximately 160 ampere hours in January and 140 ampere hours in June—no such great variation however, as we found between winter and summer months on the diner and overland coach.

Inasmuch as the greatest part of this discharge occurs in the station where the number of hours discharge is always the same and not subject to the delays that equipments enroute are, an allowance of 50% in figuring the charge required should be sufficient to cover battery losses and all emergencies. This would then amount to 240 ampere hours in January and 210 ampere hours in June.

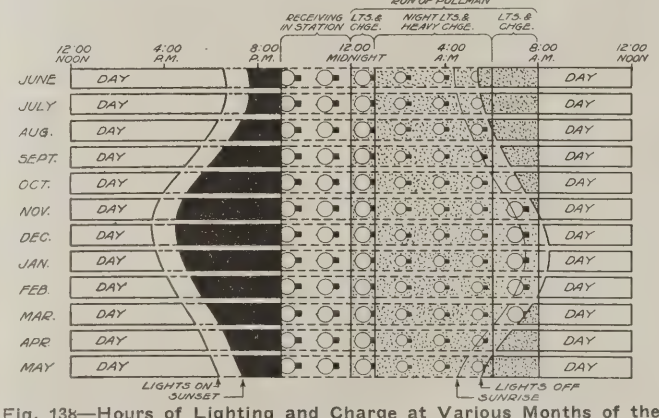


Fig. 138—Hours of Lighting and Charge at Various Months of the Year for Pullman on Night Run Only. Pullmans on Overland Runs Will More Nearly Approach Fig. 136

From the diagram it will be found that in January there are 5 hours charge with the night circuit alone in use and 3 hours charge with all lamps on. Assume a setting of 51 amperes and with 10 amperes in the night circuit, we will have a total charge of 205 ampere hours with the night circuit and (3 x 11 amperes, or) 33 ampere hours with all lights on, making a total of 238, or approximately the correct amount of charge. In June we have a charge with all lights of 1 hour, with night lights of 4¼ hours, and with no lights of ¾ of an hour. Assuming a regulator setting of 48 amperes, we find that we get a charge of (38 x 4¼, or) 161 ampere hours with the night lights, and (48 x ¾, or) 36 ampere hours with no lights and 8 ampere hours with all lights on, making a total of 205 ampere hours

total charge, which is approximately the amount required. In this particular class of service it would probably be safe to set the regulator at 51 amperes for operation over the entire year as the overcharge in summer would be too small to cause any serious trouble.

Stop Charge Device

It is obviously of great advantage to have the current regulator set at the maximum output of the generator so that batteries may receive a strong charge enroute whether the lamps are turned on or not, as this will insure quick recovery in case of failure of lights while laying in the station. Accordingly, the so called stop charge was developed for car lighting equipments a number of years ago for the purpose of stopping the charge when the battery became full, thus making it possible to set the regulator high and provide this heavy charge and quick recovery enroute without overcharging the battery.

On experimental equipments these stop charge devices operated very successfully for a time, and accordingly a great number of axle lighting devices were so equipped. Their designers, however, did not seem to give due consideration to the fact that the voltage of a storage battery is no definite indication as to the condition of charge, since it depends on so many variable factors, such as current rate, temperature, electrolyte, condition of plates, etc. In fact, during different seasons of the year, a battery kept in good condition may show a voltage at the end of charge anywhere from 36 to 44 volts *at the battery* on a 30 volt system. The voltage at the switchboard when the battery is at 42 volts may show as high as 44 volts before the battery becomes fully charged. This clearly shows the impossibility of setting the voltage stop charge device at any certain value which will meet all conditions of battery operation.

It took about two years of practical operation, involving some very costly experience for railroad companies, to learn that the stop charge relay was unsatisfactory for railway car lighting service. Incidentally, we might point to numerous articles in the *Railway Electrical Engineer,* the first issue of this publication, nearly five years ago, in which such failure was amply predicted. This failure, morever, was not due to any mechanical or electrical defects in the apparatus itself, but rather to a lack of appreciation of the fundamental principles of storage battery operation on the part of the advocates of the stop charge voltage devices.

The detail of the application of these voltage stop charge devices have been described in connection with the various systems, so will not be repeated here. There are, however, a large number of these devices still in use on car lighting systems, so we must give a word of advice as to their operation—don't depend absolutely upon the stop charge relay; set the current regulator at somewhere near the correct value, as outlined in the first part of this lesson, so that the battery will not be destructively overcharged even though the relay fails to operate. If this is impossible, on account of the uncertain operation of the car, set the voltage relay a little below normal, (about 38 in the summer time and 40 volts in the winter time) and two or three times a month cut out the stop charge device altogether so that the battery will receive an overcharge that trip.

Voltage-Current Regulators

As an outgrowth of the stop charge relay principle a combination current voltage regulating device has been developed for car lighting work, which instead of stopping the charge altogether, simply causes the charging current to taper when the battery voltage rises to a certain value.

These devices have also been described in past lessons of this course so we will not go into further detail, except to say that the regulators are usually set so as to deliver the maximum battery charge with a given output of the generator. This adjustment is usually made at the factory and need not be changed, whatever class of service car may be placed in. The voltage setting is usually 40 volts and the regulator prevents the generator voltage from going above this value. When the battery voltage reaches that point the regulator prevents further rise and the batter current tapers off on the 40 volt charge.

Although this is an improvement over the stop charge principle in that the liability to destructively overcharge the battery is greatly reduced, the variation in battery voltage conditions, as explained above, may be such that the charge may not taper at all or may even taper too soon. In other words, if the battery voltage does not rise above 38 volts, as often occurs in very warm weather, the current tapering device will not operate if set at 40 volts and the battery will continue to receive heavy overcharge.

On the other hand, a series of tests with the voltage current regulator on a certain battery have shown that a variation of from but three volts in the regulator setting 39 to 42 volts will produce a variation in the final current to which the charge tapers of from 7 to about 55 amperes.

Under ordinary conditions, the voltage at the end of charge may vary from 38 to 42 volts, depending upon temperature, condition of plates, etc., so that we may easily expect a variation in voltage due to the battery itself, to say nothing of the error in setting the voltage coil of fully 3 volts or possibly more, which may result in serious overcharging of the battery at certain times of the year. This may easily be fully equal to the variation of from 5 to 50 amperes, as found at the end of the battery charge in the above mentioned tests, and accordingly indicates the limit of success which may be expected from this system.

Ampere Hour Meter Control

Within the past year there has been developed a special type of ampere hour meter which makes it possible to automatically control the variation of any axle equipment on the ampere hour meter principle. The meter automatically provides for an overcharge of 20% in excess of the previous discharge, recording in one direction on charge, and the reverse on discharge, and when the proper number of ampere hours have been put into the battery, will operate to discontinue further charging.

On account of the above mentioned variations in battery voltage at the end of charge, it would seem that the ampere hour meter offers a more satisfactory solution of the battery charging problem in axle car lighting systems. A few of the axle equipments on one of the big roads have been equipped with the ampere hour meter and the results obtained fully justify the expectations for this type of control.

The detail of the resistor type meter will be described in our next lesson.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Testing Polarity of Generator Fields.

In the Practical Stunts column of the January issue of the *Railway Electrical Engineer,* I notice a stunt on "A Test for North and South Poles in a D. C. Generator," which is very clear. However, I have found that a compass sometimes goes crazy, and do not find many in use around railway yards, and for the needle and string method there are not many electricians that think of using same.

I have found the following method highly satisfactory and can be applied by anyone as the tools necessary are always at hand: In testing polarity of poles it is necessary to take armature out of generator, brush rigging and housings; this leaves fields or pole pieces exposed and handy for making test, knowing that fields of like polarity do not attract when energized. Now apply to the surface of pole pieces a cap wrench or pliers. If they stick when applied between any two pole pieces, the polarity is correct; if they do not stick the polarity is either two north or south poles. It is now necessary to change connections until the pliers or wrench will stick. Continue testing poles 1 and 2, 2 and 3, 3 and 4, 4 and 1; if wrench sticks on all poles as indicated, generator is connected correctly. In making the above test current must be passing through field coils. This is a quick and satisfactory test. Replace housings, brush rigging and armature and motor the generator.

S. T. Sikes,
Ch. Elec., Sun-Set Central Lines.

Repairing Auto-Switch Contact.

The other day I found a safety type "D" panel on which the copper laminated brush of the automatic switch was sticking, blowing the generator fuse at every stop of the train. I found this was due to the fact that the brush had been filed down on account of roughness, making it too short to spring properly in the space between the contact blocks.

Having no laminated copper brush for this type of switch on hand, I removed the upper contact from the panel and cut a piece of sheet copper to fit the contact block; after tinning with solder one side of the piece of copper and the face of the contact block, I placed the tinned sides together and holding them firmly with pliers, applied heat from a blow torch until they were securely soldered together. I then connected up the automatic switch and found I had a fine contact. The switch has never given trouble since.—W. B. Hoschke.

Commutator Trouble.

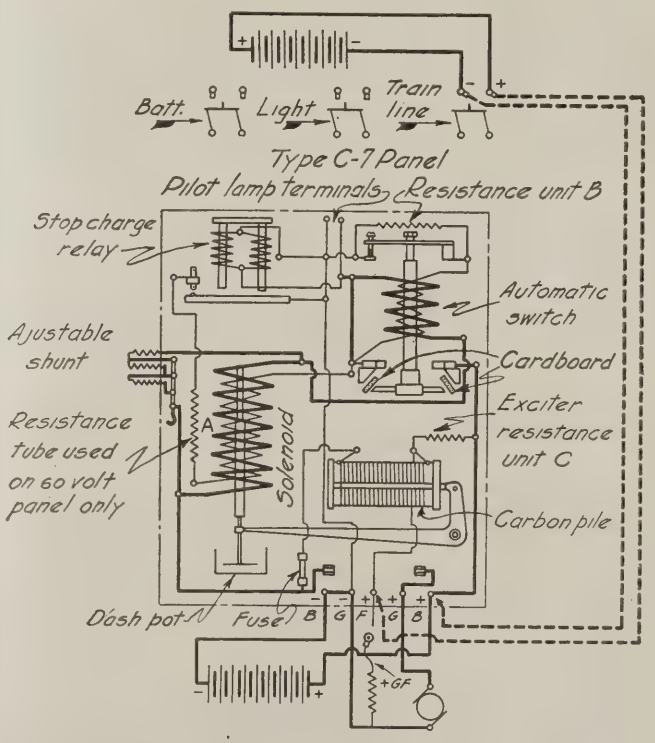
Direct current shop motors sometimes give a good deal of commutator trouble, one feature of which is the deterioration of the mica between the bars. This generally commences on the outer edge of the commutator and works in. The trouble can be taken care of in the following way:

Take a hack saw blade and break it in two, smooth up two faces and put them together, then grind both parts down for about 3 in. on the side of an emery wheel until the saw is thin enough to saw the mica out between the bars with blades placed side by side, one going as a push saw and the other as a pull saw. The back of the blades should be ground a little thinner than the cutting edge; this is the equivalent of a set, the original set having been ground off. Then saw out the mica that has deteriorated until good hard mica is reached and take mica of the proper thickness and with a little shellac plug the hole, after which the mica can be trimmed off level with the point of a sharp knife. Be sure to have the mica thick enough so that it wedges into the slot, for if it is loose it will fly out on high speed.

J. R. Pratt.

Setting Voltage Coils From Train Line.

In setting the voltage coils of either charge relay, automatic switch, or other voltage coils of the regulating panel of a car lighting system, it is necessary to have a voltage somewhat greater than the discharge voltage of the storage battery.



Wiring Diagram of U. S. L. C-7 Panel with Train Line Connections to Battery on Adjacent Car for Setting Voltage Coils

A practical means of obtaining this higher voltage is shown in the accompanying diagram, which is taken for the U. S. L. type C-7 panel.

First remove the main fuse and insulate the automatic switch by placing pieces of cardboard between the contacts; then open all three switches on the panel board to battery, lights and train line. Then put up a connection between the adjacent car and the car to be tested; open the positive field and, with a flexible lead, connect from the positive of the upper contact of the train line switch to the positive field terminal on the board and from the negative train line contact to positive battery, as shown in the diagram. This connection then places the battery in the adjacent car in series with the battery on the car

to be tested and the combined voltage of the two batteries then comes across all of the voltage coils on the regulator board. The carbon pile of the field regulator, however, is in this circuit so by compressing or releasing the pressure on this pile by hand the resistance may be adjusted so as to bring the voltage across the relay coils to any desired value.

With the carbon pile compressed as far as possible there will be a potential of 58 to 64 volts across the coils, but by slowly decreasing this resistance the voltage may be carefully adjusted to any desired value in setting the automatic switch, stop charge relay or potential coil.

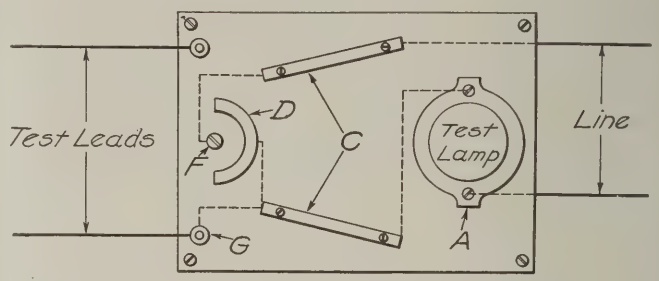
This device may also be employed in setting the main potential coil of the generator, which prevents the voltage of a generator from rising above a certain value by releasing the pressure on the carbon pile. It is evident from tracing the diagram herewith, that the main potential coil which controls the pressure on this carbon pile which is now placed in series with its own current, will come to a balance by releasing or increasing the pressure on the pile until the voltage across the coil is that for which the regulator is set. By increasing or decreasing the spring tension or other device of the coil, the balance, or in other words, the setting of the potential coil, may be varied.

It should be remembered, however, that when this voltage coil is operating there will be a certain amount of current flowing through the series solenoid, the magnetism of which will add to that of the shunt coil and reduce the voltage of the generator. This varies, depending upon how much current is desired at the end of charge, and the setting of the voltage coil should be correspondingly high and above the voltage desired as a maximum for the generator.

In setting all shunt coils they should be allowed to warm up to as nearly as possible operating temperature before starting.—L. D. Smith.

A Practical Test Board.

In the enclosed diagram is given a practical test board which I have found very useful for testing motors, electric flat irons, fixtures, etc., for shorts, open circuits, grounds, etc., and also for testing lamps and fuses.



Test Board for Lamps, Fuses, Grounds, Shorts, Etc.

The base which is made of slate or hard wood well shellacked, can be mounted on the wall or bench as desired, by screws through four No. 5 porcelain knobs. At one end of the board is mounted a wall receptacle to hold the test lamp (B); 2 strips of metal (C) placed at an angle as shown serve as terminals for testing all sizes of enclosed fuses up to 600 amperes; a small circular piece of metal (D) and a screw (F) can be used as terminals for testing lamps and plug fuses. The test leads can be attached to the binding posts (G) at the left end of the board and run to the motor or fixture to be tested.—F. Phipps, Montreal.

Prize Question Box

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

Better send in your questions now, while you think of it.

Questions Before the House

Care of Ball Bearings.

Since the grease gun has not been found satisfactory for car lighting generators, on account of the fact that it is able to force grease out of the housing into the generator case itself, it has become the practice on some roads to grease the machines only at intervals of six or eight months, at which time the heads are opened, bearings taken out and cleaned and regreased. There seems to be more or less diversity of opinion as to the best method to be followed, whether to shop the generator and give them a complete overhauling, or to simply remove the heads and regrease the bearings without removing same from the car.

It would be interesting to hear the comments of different car lighting men on this subject.—L. S. Billau.

Axle Generator Alignment.

I should like to obtain some information through the Question Box covering quick and easy methods of checking the alignment of axle generators with reference to car axles and which are suitable for use in checking up cars in service and undergoing periodic inspection.

Methods I have seen involve measurements beween axle equipment and the rail or the car axle itself, both of which are apt to result in error if the axis of the axle is not at right angles to the rail or in case the axle is not at right angles to the pedestals due to lost motion in journal boxes, etc.—L. S. Billou, Elec. Dept. B. & O. R. R.

First Prize

Voltage Drop in Train Lines.

Ques. In a three wire return loop system, such as is employed in the train lines of railway car lighting work, do all cars in the train receive the same voltage?—H. B. K.

Ans. Although the return loop system which is employed in all head end train lighting systems is known as the equi-potential system, all cars in the train do not receive the same voltage; the center cars receive a slightly lower voltage than the car either at the rear end or the forward end of the train.

Reference to the accompanying diagram will explain why this occurs. For the sake of simplicity, the criscrossing of the train lines in both the cars and the train line connectors is omitted, and each car is represented by a circle. Assume a train having 10 cars back of the dynamo car, wired with No. 0000 train lines, and the lamp load on each car is exactly 10 amperes. There

will then be 100 amperes generated, which will flow through the positive train line to the rear of the train, 10 amperes branching off at each car. We will also assume that the lamp current for each car is tapped off the train line at the rear of the car in each case. We will then have, as shown in the diagram, 100 amperes flowing through the positive lead in the first car back of the dynamo car. Since 10 amperes was fed to the

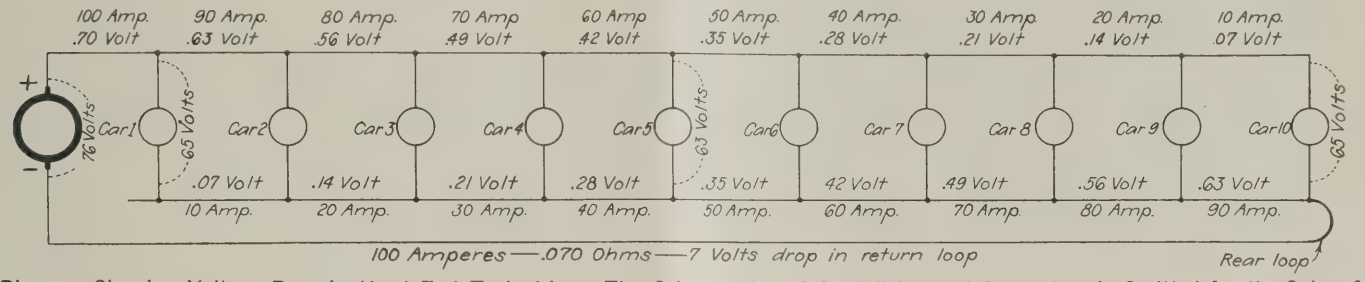


Diagram Showing Voltage Drop in Head End Train Line. The Crisscrossing of Car Wiring and Connectors is Omitted for the Sake of Simplicity. Note That Front and Rear Car Have the Same Voltage, but the Center Car is 2 Volts Lower

lamps of the 1st car, there will only be 90 amperes flowing through the positive lead of the 2nd car, and since 10 amperes of this feeds the lamps of the 2nd car there will be only 80 amperes flowing through the positive lead of the 3rd car, 70 in the 4th, etc.

The resistance of the train line, No. 0000 stranded copper wire, is found from wire tables to be .00005 ohms per foot, or .00035 ohms for each train line in a 70-ft. car. Practical experience has shown that there is also a voltage drop in each train connector; this varies with the amount of dirt and corrosion on the copper contacts, but for the sake of simplicity we will assume that the resistance of both the contacts of the train connector is the same as the resistance of the No. 0000 train line in one car. This will make a total resistance per car of .0070 ohms for each train line, including both wire and connector.

In the first car, with 100 amperes flowing, the voltage drop in this positive train line would then be the current times the resistance ($100 \times .0070$) or .7 of a volt. In the second car there is only 90 amperes flowing in the positive lead and 10 in the negative, so the voltage drop in the positive would be 90 times .0070, or .63 volts; in the negative train line of this same car, which carries only 10 amperes, the voltage drop would be $10 \times .0070$ or .07 volt. In car No. 3 the voltage drop, in the same way, is found to be .56 volt in the positive lead and .14 volt in the negative; in car No. 4, .49 volt in the positive, train line and .21 volt, in the negative, etc. (see diagram).

The voltage across the lamps in any car is obviously the voltage of the generator minus whatever voltage drop occurs in both positive, negative and return loop train lines leading to that car. Take, for instance, the lamps in car No. 1, we find that there is .7 volt drop in the positive lead of the first car, but as the current for this car must then flow through the negative train line to the rear of the train and through the return loop to the generator negative, the voltage drop is the sum of the drop in positive line in car No. 1 and the individual drops in the negative train line of each car, and return loop, or the sum of 0.70, + 0.07, + 0.14, +0.21, + 0.28, + 0.35, + 0.42, + 0.49, + 0.56, + 0.63, and .7 volts drop in the return loop, or a total of 11.03 volts total drop in the complete circuit of the current flowing through car No. 1.

By following the flow of current to the middle car of the train, car No. 5, and adding the voltage drop in the train lines through which this current passes, (positive train lines in cars 1, 2, 3, 4, 5 and negative in cars No. 6, 7, 8, 9, 10 and the return loop, see diagram), it is found that there is a total of 12.96 volts drop in this circuit.

And similarly if the circuit of the current flowing through the lamps of car No. 10 is carefully followed out and the individual voltage drops in the train lines through which this current passes are added (positive train line in all cars and back through return loop), it is found that the total drop for this car is 11.03 volts, the same as for car No. 1.

Now then, if the generator voltage is adjusted to 76 volts, the voltage on the lamps of car No. 1 will be 76 minus the 11 volts drop in the train line, or 65 volts; on the other hand, the voltage across the lamps in car No. 5 will be 76 volts minus the drop in the train lines to that point, (12.96 volts) or approximately 63 volts; and similarly it is found that the voltage on the lamps of car No. 10 is 76 volts less the drop in train lines to that point (11.03 volts) or 65 volts, the same as car No. 1. The voltage of other cars in the train can easily be figured out.

It is thus seen that the lamps in the middle cars of the train receive a somewhat lower voltage than the cars at the front or rear of the train. Obviously as the total lamp current is reduced the difference in voltage between the end cars and middle cars will be correspondingly reduced.

Second Prize

Loss in Capacity of Negatives.

Ques. What should be done when the negative plates of a battery lose capacity, and what is the best means of locating the trouble? J. G. Koppel.

Ans. Every time a storage battery is cleaned a capacity test should be made to determine the total capacity of the battery at that time. This test is always made in the battery house with all the covers off the cells. Voltage readings of each cell should be taken and recorded every half hour on both charge and discharge. These readings will show up any irregularities in individual cells, which may be remedied.

Cadmium test readings should be taken on each cell as described in our June, 1912, issue, lesson No. 5. It will be well to refer to this lesson in order to understand the test. Where the cadmium to negative readings are abnormally high on discharge (between .2 and .3 of a volt) it indicates that the negative plates are in trouble. This usually is caused by the negatives becoming hardened; they need loosening up. The method of doing this is described under "Hardening of Negatives" in lesson No. 4, May, 1912. If the plates are badly hardened, that is, so that after one or two strong charges and discharges the cadmium to negative on discharge does not show approximately .2 of a volt or lower at the end of discharge, remove the negatives from the cells and, placing them in other tanks with sets of blank sheet dummy plates, reverse the negatives, charging them as positives,

and again reversing so as to make the plates negative. One or possibly two such reversals should bring the negatives back to full capacity.

Third Prize

Kennedy Regulator Trouble

Ques. Would the field resistance of the Kennedy regulator, with the arm stuck about half way around, cause the generator to reverse in the opposite direction to what the pole changer is set? Thomas Rockey.

Ans. With the type "D" generator equipment the frame is of cast steel and should retain enough permanent magnetism to maintain the fields always in the same direction. With the high resistance in circuit, such as you would have with the field resistance contact arm stuck in the half way position you speak of, it might prevent the generator from building up, but this could never cause the generator to reverse polarity.

U. S. Regulator Panel.

Ques. Do the units on the back of a U. S. regulator panel S-2 carry current when the machine is in operation? J. L. P.

Ans. Referring to the diagram on page 279 of the December issue of the *Railway Electrical Engineer,* it will be seen that there are five resistances, "B," in series with the lifting coil of the automatic switch; D, in series with the coils of the potential regulator; E, in series with an auxiliary circuit for the generator field; G, in series with the coils of the lamp relay; and A, connected in series with the generator field, but normally short circuited by the lower magnet bar of the potential regulator. Current will flow through "A" only when the battery is charged and the generator voltage rises high enough to cause the potential regulator to pick up its lower magent bar; this will open the circuit at "A" and cause current to flow through this resistance. Current will flow through "B" all the time the automatic switch is closed; through "D" all the time the generator is operating; through "C" whenever any lamps are in use, and through "E" when the car is at rest and the generator dead.

A Reversed Cell.

Ques. I wish to refer to the second prize question of your November Question Box in regard to the negative plates turning brown. What would be the result of simply reversing the connections on a cell in that condition? C. H.

Ans. The only correct way to handle such a cell is to remove the cause of the trouble, that is by taking the elements out and removing either the lead tree formation between plates or the sediment in the bottom of the tank which is causing the cell to discharge and then renew the electrolyte if it is contaminated.

A collection of sediment at the bottom of the tank, deep enough to touch the plates, or a lead tree formation between plates, or even a copper or iron impurity in the electrolyte will cause a local discharge current to flow continuously in that particular cell affected. This will partly, or wholly discharge that cell so that when the lights are fed from the battery, this cell in trouble will soon become completely discharged, while the other cells of the battery may have nearly full capacity left. So the discharge current keeps right on flowing through this cell even though it is completely discharged; this has the effect, on this particular cell, of a charging current in the wrong direction which will reverse the plates of that cell, making the negatives positive, and the positives negative.

In a Plante battery, as explained in our lesson No. 5, June, 1912, both positive and negative plates are formed originally as positives and simply reversed to make the negative elements. So as far as this particular cell is concerned, there would be no damage done by reversing the connections as suggested where a Plante plate is used in both positive and negative elements. It would be very bad practice, however, from the standpoint of battery maintenance, as the connections to all cells should be uniform. But in any event, you would be just as bad off as you were before; the local discharge will continue and that cell will be discharged and again be reversed in the wrong direction as before, when lights are turned on.

Leaky Battery Tanks.

Ques. Why do the front cells of a car lighting battery become leaky more than the back ones?

Ans. If you remember, one of the questions in our November, 1913, "Prize Question Box" asked why the back cells of a battery developed more leaks than the front ones. We answered that question by stating that it was harder to fill a cell at the back than one at the front and so they were usually filled too full, often slopping over and causing the cells at the back to become soaked and develop grounds, which finally cause the tanks to pit.

This case is just the reverse of the above question, but upon further questioning it was found that the practice upon that road was to wash off the fronts of the battery tanks with a hose when they were flushed. This, of course, left the front end of each tank in a soaked condition which soon developed grounds and pitted the tanks just as explained in the other case where it was the rear cells.

In other words, it is bad practice to allow either the front or the rear end of the battery tanks to become soaked as this will soon develop grounds. Keep the battery compartment and all tanks as dry as possible.

Short Circuited Field.

Ques. What would be the effect in motoring a car lighting generator of the Bliss system if one of the fields were short circuited? Can this trouble be located with a voltmeter if a slight current is past through the fields? Electrician Sunnyside Yards, New York.

Ans. A short circuited field coil would mean that practically no current would pass through that particular field coil and accordingly no magnetism would be generated in that coil. The magnetism from the two adjacent coils, however, would cause a fairly heavy magnetic flux to flow through this pole even though there were no current flowing through the field winding. This would give a lopsided field, which would undoubtedly cause rather severe sparking when the machine is motored and the armature would tend to run away.

This trouble can easily be located with a volt-meter or by connecting the voltmeter leads to each of the coil terminals. It would be found that one coil shows either no voltage at all, or a voltage very much lower than the other coils. This would indicate that that coil is short circuited.

Treatment of Overhead Battery.

Ques. Why is it that a battery once overheated and overdischarged cannot be brought up to full capacity until the plates are taken out, washed and recharged with new acid?

Ans. Both the overheating and the overcharging would tend to sulphate the plates, but a regular treatment of charging to remove sulphation should be sufficient. The mere fact that the battery has been overheated does not affect the acid other than making it slightly weaker because some of the sulphate of the acid has gone into the plates and accordingly it should not be necessary to renew the acid unless there are actually some impurities contaminating it.

Personal Mention

William F. Bauer

The Edison Storage Battery Company announce the recent appointment of Mr. William F. Bauer, as assistant manager of the railway department, with headquarters in Chicago. Billy is one of the original pioneers in the car lighting game and his many friends in this line will be pleased to learn of his appointment.

William F. Bauer

In the early days around in 1885, Billy played baseball and was one of the stars of the Boston team, but when things were brought more to a commercial basis in that line and Buffalo tried to get him, his father said "Nix," so that was the end of Billy's fame as a baseball star.

Way back in 1889 Billy was the electrician in charge of the original train lighting equipment on the Chicago Limited of the Pennsylvania Railroad. It was equipped with an Eikmeyer dynamo and brotherhood engine, a system designed by his father, then chief electrician of the Pullman Company in Chicago. A few cars had a storage battery auxiliary of the pasted plate type.

In 1891 he went to the Newark factory of the old Electric Accumulator Company, who manufactured pasted type batteries, continued with this company, until 1893, when he was employed in the Railway Department of the Westinghouse Electrical Manufacturing Co.

After his father's death in 1895 he went back with the Pullman Company as electrical foreman of the Waldo Avenue passenger yards in Jersey City.

In 1897 he became train electrician of the Lake Shore Limited, being then in the employ of the Wagner Palace Car Co. At this time he took the first electric lighted train on the Lake Shore from Chicago to New York. He left his work in 1900 to accept a position as electric station foreman of the United Electric & Traction Co., at Baltimore, but in 1901 came back into the car lighting game with the Consolidated Railway Elec. Lighting & Equipment Company and put the first car lighting equipments on the Frisco Lines and the Missouri Pacific Railroad. In 1903 he was appointed chief electrician of the Missouri Pacific R. R. in charge of car lighting. In 1906 he came to Chicago as sales engineer of the Chicago office of the Electric Storage Battery Co., and in 1908 went with the National Battery Co., which was absorbed a little later by the U. S. Light & Heating Co. He has been in charge of the Chicago office of this company up to the present time.

He has always been very active in Association matters ever since the organization of the old Car Lighting Engineers' Association, and in 1912 was elected junior vice president of the Railway Electric Supply Manufacturers' Association, and at our last convention was elected senior vice-president.

J. E. Gardener

Mr. J. E. Gardner, recently appointed Electrical Engineer of the C., B. & Q. R. R., was born in Exeter, New Hampshire, in 1882. In 1900 he went to Harvard College and after graduation in 1904, spent a year in

J. E. Gardner

the Lawrence Scientific School, graduating from that institution in 1905.

After several months spent in the Lynn Works of the General Electric Company, Mr. Gardner came to the C., B. & Q. R. R. as a special apprentice. After completing this course, he was employed at the Aurora Shops of that company until 1911, when he was transferred to the staff of Mechanical Engineer for special inspection work. He was appointed Electrical Engineer of that company in March, 1913, and has become an active member in the Association of Railway Electrical Engineers. It is men of Mr. Gardner's calibre who give the association its reputation for high grade work and make it an important factor in the railroad world.

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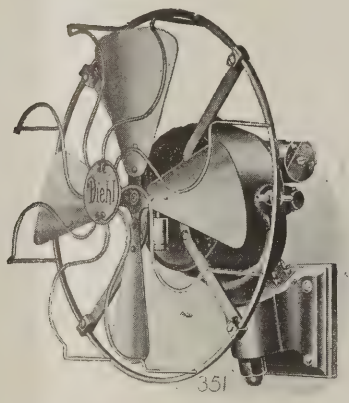

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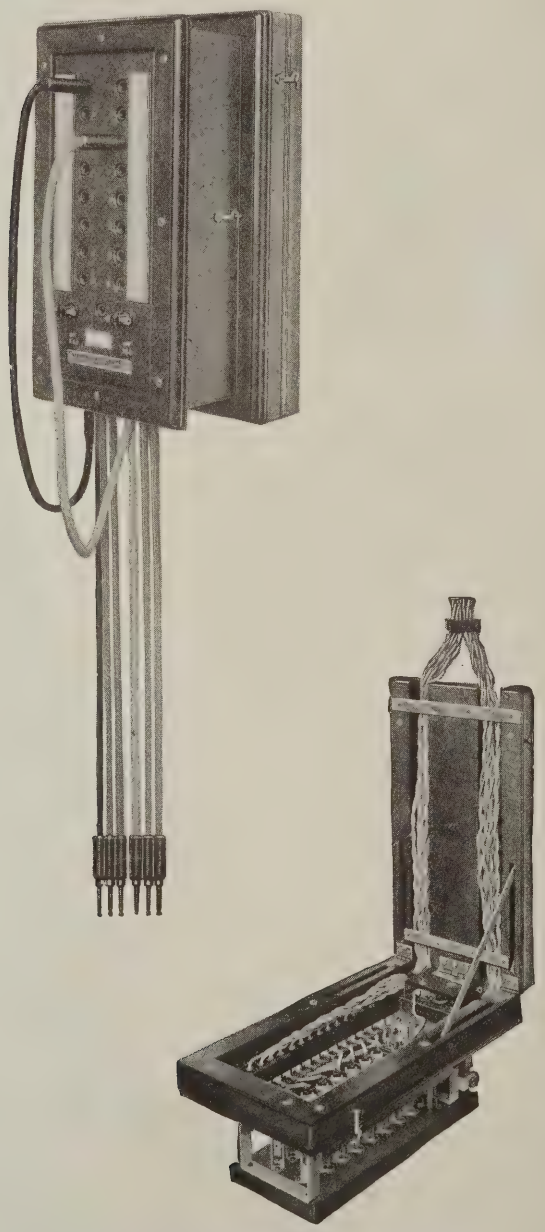
RAILWAY WAY-STATION TEST BOARDS.

An important part of the equipment of the railway way-station operator's office is a ready means for testing and patching the telephone train dispatching circuits, so that interruptions to service may be minimized and a remedy quickly applied should such interruptions occur. To meet the demand for an efficient testing and patching device of this kind, the Western Electric Company has developed and placed upon the market what is known as the No. 2 type Test Board.

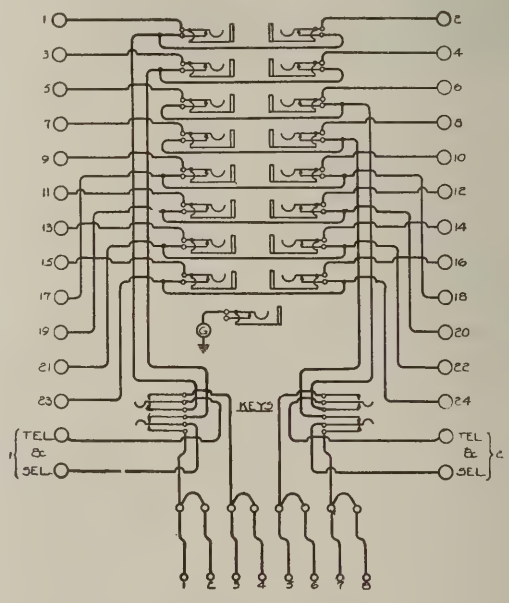
These test boards, the No. 2-A equipped for two metallic circuits and the No. 2-B for four metallic circuits, are made of solid oak and built to withstand more than the ordinary amount of use. The jacks through which the lines are carried are mounted in the face of the board, each with its designation strip. Below these jacks are mounted keys by means of which the selector and telephone equipment is switched from its regular circuit to the patching cords. The patching cords are connected to terminals inside of the test boards and hang from the bottom of the cabinet. These cords are thoroughly moisture proofed. Wiring is run in twisted pairs and held in place by removable straps.



No. 2 Type Test Board, Cover Removed and Board Opened for Inspection

A feature of the No. 2 type test boards is their accessibility for inspection work. A removable cover held in place by hooks gives immediate access to all line terminals, while the apparatus board hinged at the lower edge gives access, when opened to the jack terminals. All wires are visible for inspection when the apparatus board is opened.

The design of the test boards is the result of a careful study of railroad dispatching conditions. It has been found to be general practice to carry the train wire and



The Circuit of No. 2 Test Board

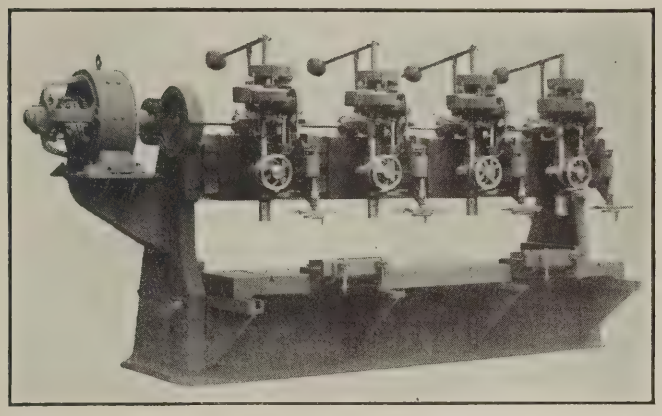
message wire through the test board, provided two circuits of this kind are installed. If no message wire is installed, it is usual to take two telegraph circuits of iron wire, solder all the joints and transpose the circuit and then bring it through the test board so that it may be used for patching. The telegraph wires may also frequently be brought into the test board even if a message wire has been installed. The point in this is that the train wire, which is the most important, must be kept working in any event, making it necessary to carry the message and telegraph wires through the boards so that they can be used for patching in emergencies.

The No. 2 test boards are equipped to make all the tests and patches ordinarily required on train and message wires. They are an essential for roads with a heavy wire traffic where an interruption to service is a serious matter.

MOTOR-DRIVEN MUD-RING AND FLUE-SHEET DRILL.

The accompanying illustration shows a Foote-Burt 4-spindle drill installed in the Juniata Shops of the Pennsylvania Railroad, where it is used for drilling the rivet holes around fire box mud-rings and the flue holes in boiler flue sheets.

The heads of this machine have an adjustment in and out from the main cross-rail of 12 inches. They are also adjustable on the main rail up to a minimum center distance of 18 inches. Both of those adjustments are controlled by individual hand-wheels shown on the front of each slide.



Mud-Ring and Flue Sheet Drill

The heads carrying the spindles are complete in themselves as each is arranged with a clutch for stopping and starting. Also each is fitted with geared power feed with adjustable stop for automatically knocking off same at any desired point. Two changes of power feed are provided on each head, either one of which is instantly available by simply shifting a lever conveniently located. In addition to power feed each spindle is furnished with hand feed through worm gearing.

The motor is of Westinghouse make, 20 horsepower and with speed adjustment of from 375 to 1500 r. p. m. It is geared direct to the drive shaft by a large spur gear and a rawhide pinion, both of which are guarded.

The weight of the machine is 23,000 lbs.

TWENTY-FIVE YEARS OF STORAGE BATTERY BUILDING.

This is the title of a silver anniversary bulletin recently issued by the Electric Storage Battery Company. The book is beautifully illustrated and no expense seems to have been spared in making it a volume of a quality commensurate with the occasion and the reputation of that company. The book covers the whole development of storage battery practice prevailing since the organization of the company in 1888, down to the present time. Some of the pioneer battery installations and detail of early battery construction are shown in comparison with modern practice.

Some of the special developments auxiliary to the storage battery, such as motor driven end cell switches, recording and signaling hydrometers, carbon regulators and the new E. S. B. axle lighting system are also described.

The reader is then taken for a stroll through the factory and all of the various processes are carefully described and clearly illustrated. Photographs of the various officials with a brief sketch are shown and the book closes with a panoramic view of the factory during the noon hour, showing a host of employes.

MUDGE & CO. NOTES.

Mudge & Company announce the termination, effective January 1st, of their contract for the manufacture and sale of Garland Ventilators and other Garland devices.

Mr. Thomas H. Garland has resigned as Vice-President of Mudge & Company and will devote his time to the manufacture, sale and improvement of the Garland Ventilator as well as the other devices of which he is the inventor.

George W. Bender, who has been General Manager of Mudge & Company in charge of their Manufacturing Department, will also, effective January 1st, have full charge of the Sales Department, Mr. Robert M. Smith, General Sales Manager, having resigned and this position having been abolished.

NEW "RALCO" TWIN RECEPTACLE.

The constant demand from electrical engineers for a twin receptacle, with housing, resulted in the development by the Central Electric Co. of a Ralco twin receptacle, both fused and fuseless. The No. 15 Ralco consists of two 30-ampere receptacles fitted into a cast iron box 6 in. x 8 in. x 2¼ in. deep. In the design of the box special attention was given to the ease with which it could be wired, and to assist the electrician, ample space was provided for that purpose. The box is primarily designed for inside use, and is fitted with ¾-in. knockout on two sides and top. If the receptacle is required for outside use, it can be made waterproof.

The No. 16 is identical in construction to the No. 15, except that the box is 9¼ in. x 8 in. x 2¼ in. deep, with

New "Ralco" Plug Receptacle

space on top for either one or two No. 91102 D & W cutouts. When equipped with one cutout the boxes are marked 15 amperes per plug; when equipped with two cutouts, 30 amperes per plug, because the fuse block governs the rating. Although shown in cut with one cutout, unless otherwise specified in order, the No. 16 is furnished with two No. 91102 D & W cutouts, and marked 30 amperes per plug. Fuse blocks and receptacles come wired, so that all that is necessary in order to install it, is to bring the line wires down to the terminals of the fuse block. A door is provided in front in order to make it easy to remove a fuse when blown.

The No. 15 and No. 16 Ralco are especially desirable around railroad machine shops, where two portable light outlets or portable motor outlets are required. The saving in time in mounting the receptacles, as compared with the single units, where two outlets are required, is very marked.

The above shows Eye Comfort Lighting installed in the C. R. I. & P. Dining Cars.

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Every provision for the comfort of the traveler is discounted unless good lighting is provided. And good lighting is only possible with indirect illumination. The only way to solve the lighting problem for railway cars economically and effectively, is to use the Eye Comfort Lighting System.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Constant Potential Method of Battery Charging

The report of the committee on Methods of Battery Charging, made at the annual convention of the association last fall, contains some rather radical recommendations on the matter of battery charging. For straight storage, yard charging and head end system, the constant potential method of charging was recommended as containing certain features of advantage over the constant current method, which has been so universally used up to recently. The appendix to this committee report, as given in an article on this subject in another part of this issue, contains much information of direct interest and value to the electrical engineer in charge of car lighting work.

Charging a storage battery is very much like filling a glass of water; it can be filled in the shortest possible time and with the least overflow by turning it on full force at the start and gradually diminishing the rate of flow until the glass comes up to full measure. When a depleted storage battery is placed on a constant potential charging system a heavy current will flow at the start but this will taper off to a certain value, depending upon the charging voltage and the resistance in circuit.

As far as simple cost of installation is concerned, the series method of charging is undoubted for cheaper than either the constant potential system, as outlined in the above mentioned article, or than the constant current system in which each battery circuit is controlled separately.

There can be no objection to series charging where the storage batteries receive the same amount of discharge daily, such as would be experienced with cars operating in the same train. But as a general proposition for wiring a yard on the series charging principle, where 3 or 4 cars are to be charged in series, the storage batteries of which may be in all various conditions of charge from the fully depleted battery to one having a charge of nearly its full capacity, this system cannot but seriously damage the storage batteries and cause an excessive waste of charging current.

With the constant current individually controlled system having a circuit running to each charging plug, the service from the battery point of view will undoubtedly be very much improved over the series system, but the waste of power will probably be nearly as great as with the series system; for it is not only necessary to absorb the difference between battery voltage and whatever charging voltage is available from the central station or other source of power, but there will usually be a waste due to needless overcharge on certain cars.

With the constant potential system, such as outlined in this article, it may appear that the cost of installation is excessive; this, in comparison with the constant current system, being on a ratio of $106,000 to $75,000. In considering the cost of the power wasted in the constant current system, however, this, at the 2 cent rate would amount to something over $1,000 which, capitalized at 5 per cent, would nearly warrant the difference of $30,000 in first cost between the constant potential and the constant current systems for this particular installation.

When considering the subject from the battedy point of view, the saving in battery depreciation, due to the improved methods of charging by the constant potential system, will be far greater than the mere saving in charging current and this latter point is undoubtedly the final argument in favor of the constant potential system.

Further, when the ampere hour meter is employed to stop the charge at the proper time all excessive overcharge is eliminated and a saving in charging current thus effected as well as greatly improving battery life.

From the consideration of the recording meter curves it would seem that the resistance in series with the battery might be reduced somewhat with an accompanying reduction in bus-board potential. This would cause the charging current to start at a higher value and taper to a lower value. Variation in battery conditions, as found in actual practice, undoubtedly influenced the designers of this particular system in selecting 93 volts as the working potential.

2400 Volt Electrification

of the Butte, Anaconda & Pacific Ry.

The Butte, Anaconda & Pacific Railway is, in many ways, the most remarkable example of steam road electrification in this country. Besides being the first 2,400 volt direct current road, it is also credited with being the first steam road operating both freight and passenger schedules, to electrify its lines purely for reasons of economy. A number of steam railway electrifications have been made because of peremptory factors, such as terminal and tunnel operation or for rapid suburban service. This road, however, cannot be classed as an "enforced electrification," since no such special limitations have been the determining factors.

The first electric locomotives were put in service May 28th, 1913, hauling ore cars between the East Anaconda yards and the smelter. During the first seven months of service, they made approximately 201,000 miles and hauled about 2,365,000 tons of ore.

For a distance of 16 miles, the road is paralleled by the transcontinental lines of the Northern Pacific, and the Chicago, Milwaukee & St. Paul. The last named company has already contracted for power for the operation of electric trains from Harlowton, Mont., to Avery, Idaho, a distance of 440 miles.

The maximum curvature on the system (20 degrees, 285 ft. radius) occurs on the Butte Hill line. On this part of the road, there is an average curvature of 6 to 10 degrees. The locomotives are designed with sufficient flexibility to take a curve of 31 degrees (180 ft. radius) at slow speed.

Train Service.

The freight traffic consists largely of copper ore and amounts to more than 5,000,000 tons per year. This material is handled in steel ore cars weighing about 18 tons and having a capacity of 50 tons each. Trains of 30 loaded cars weighing 2,000 tons are made up at the Butte Hill yards and hauled by two-unit locomotives to the Rocker yards, where 4,000-ton trains are made up for the main line. At the East Anaconda yards, the trains are again broken up and 1,400-ton trains are sent up Smelter Hill to the ore bins. All of the shifting and "spotting cars," at the smelters and in the sorting yards, is done by single locomotive units. The customary train makeup for both east and west bound traffic is shown in the accompanying table:

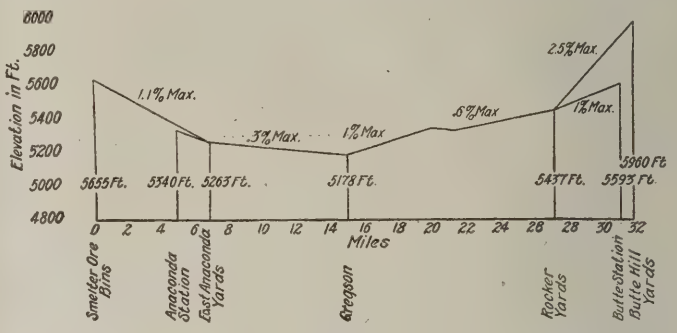
Condensed Information of Freight Movement.

	WEST BOUND			EAST BOUND		
	Butte Hill Line	Main Line	Smelter Hill	Smelter Hill	Main Line	Butte Hill Line
Trailing load in tons....	2,000	4,000	1,400	1,000	1,260	650
Number of cars.....	30	60	20	55	70	35
Number of 80-ton locomotives per train	2	2	2	2	2	2
Approx. grade against load	2.5%	0.3%	1.1%	1.1%	1%	2.5%
Approx. speed on level tangent track, m.p.h..	....	21	....	....	25	....
Approx. speed on max. grade	12	16	16	20	16	16
Average trolley voltage.	2,200	2,200	2,200	2,200	2,200	2,200
Length of run in miles..	4.6	20.1	7	7	20.1	4.6

Eight passenger trains per day are operated between Butte and Anaconda, four in each direction. The main line trains were first hauled by electric locomotives on October 1st, 1913, and promptly demonstrated their ability to make better time than was possible with steam engines. Single locomotives are used, hauling trains of from three to five passenger and baggage cars.

Power Supply.

Energy for the operation of electric trains is purchased from the Great Falls Power Company. The generating plant is located at Great Falls, Mont., on the Missouri river, and has for some time been supplying electric power for the operation of the mines and smelters at Butte and Anaconda. Six hydroelectric units are installed, having a nominal rated capacity of 21,000 kw. The power is stepped up to 102,000 volts



Profile of Main Line with Extensions to Butte Hill Yards and Smelter Bins

for transmission to the transformer substation at Butte, a distance of 130 miles, over two separate parallel lines constructed on the same right-of-way. An extension of the system transmits power at 60,000 volts to a second transformer station at Anaconda, 26 miles farther on.

It is an interesting fact that the railway load was taken on without any increase in the high tension transmission facilities. It is estimated that the additional load from this source is approximately 20 per cent. of the railway, industrial and lighting load furnished by the street railways, mines and smelters at Butte and Anaconda.

Railway Substations.

The two existing substations at Butte and Anaconda were used to house the 2,400 volt motor-generator sets required for operating the electric trains, so that no additional buildings were constructed for this purpose. Power is furnished by two 1,000 kw., 3-unit motor-generator sets in each substation, taking power from the 2,400 volt A. C. buses. These units operate continuously 24 hours per day, seven days of the week, to supply the necessary current for train operation. Each set consists of a 3 phase, 60 cycle, 1,450 kv-a., 720 rpm., synchronous motor direct connected to two 500 kw., 1,200 volt generators, insulated to operate in series for 2,400 volts. The generators are compound wound and have both commutating poles and compensating pole face windings. These fields are connected on the grounded side of the armature, and the main fields are separately excited from 125 volt exciters.

The 1,200 volt generators are provided with heat-proof insulation and, owing to their unusually good commutating characteristics, will carry three times normal load for periods of five minutes, as well as the usual 50 per cent overload for two hours.

An automatic voltage regulator is used to maintain an approximately constant voltage at the terminals of the motor by power factor regulation. The motors are protected against overload by inverse time limit

relays, which are set to open at four times normal load. These relays have been adjusted to open under sustained overload in about 2 seconds and upon short circuit their action is practically instantaneous.

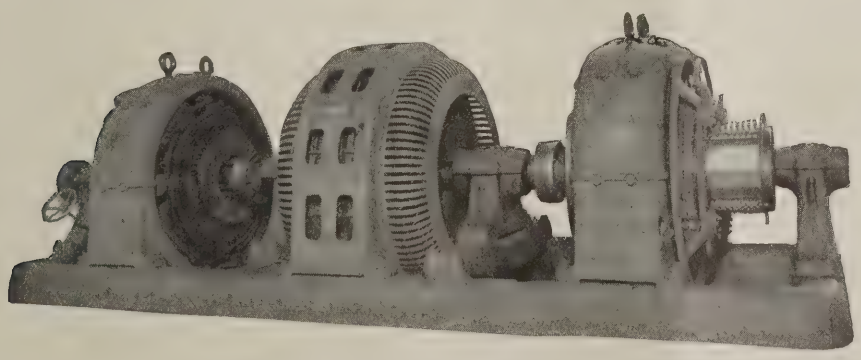
Excitation for the two generating units in each sub-

A Train Enroute

station is obtained from two induction motor driven sets, rated 50 kw. each at 125 volts. One set is used for supplying current to the synchronous motor fields and is controlled by the automatic voltage regulator. The second unit supplies current to the separately excited fields of the direct current generators.

Switchboards.

The 2,400 volt switchboards for controlling these sets are the first direct current boards to be constructed for this high voltage. In general, they are similar to the standard 600 volt type with increased insulation and special provision for interrupting the 2,400 volt current. The circuit breakers and switches are also arranged for remote control, and all apparatus on the panels is provided with ample insulation to insure safety to operators.



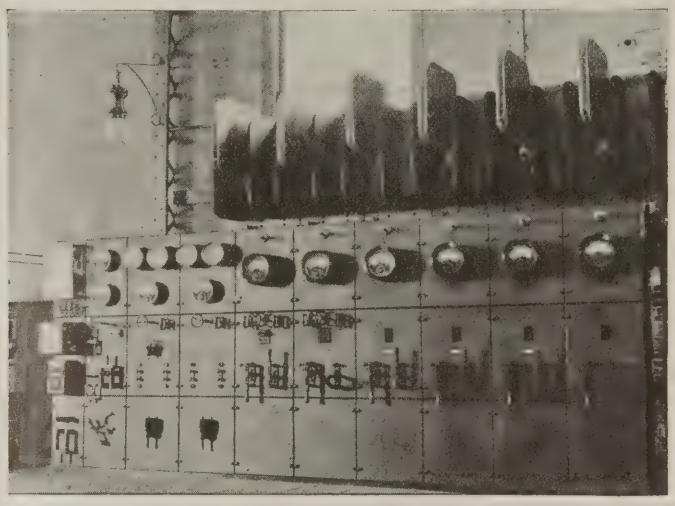
A Three Unit Motor Generator Set with Two 1,200-Volt D. C. Generators Connected in Series to Supply the 2,400-Volt D. C. Line

The 2,400 volt circuit breakers and switches are installed on separate panels above and back of the main panels, and are operated by connecting rods from handles mounted on the front of the main switchboard. These handles are similar in appearance; and to avoid confusion, the circuit breaker handles are inverted. The breakers are equipped with special magnetic blowouts and are chutes, and provision is also made for automatically inserting a high resistance in the generator field at the same instant the main circuit breakers open, thus reducing the generator voltage.

The alternating current switchboard contains two panels for controlling the synchronous motors by means of remote control, solonoid operated oil switches; two panels for the motor fields, and a panel for the automatic voltage regulator. Those panels also contain other necessary instruments, including frequency and synchronism indicators, ammeters, wattmeters and relays.

Overhead Construction.

The overhead construction for this system was especially designed to give the flexibility necessary for satisfactory operation of the pantograph trolleys used on the locomotives. The 4-0 grooved copper trolleys used over all tracks is supported by an eleven point catenary suspension from a strained steel messenger



Sub-Station Switch Board

cable. Both side brackets and cross span construction are used as required by the local conditions. There is a large amount of special work on account of the many yards and sidings, and in one case twelve tracks are spanned. The cross span construction used at this point is supported by a third pole between the eighth and ninth tracks. The hanger used on the straight line construction is a rolled steel strap looped over the messenger wire. This loop is closed at the car and the wire is clamped in place by a single bolt. Special pull-offs are used to increase the flexibility of the suspension.

The section breakers were designed for the 2,400 volt service, and at six points insulated crossings are necessary at the intersection of the 2,400 volt trolley with the 600 volt trolley of the city system. On the main line a very simple section insulator is used. This consists of paralleling the two trolley wires from the ends of each section at a suitable distance for insulation so that the pantograph bridges the two circuits for a short distance, thus avoiding interruption of the power supply to the locomotive. The construction in the yards and sidings is simplified by paralleling the trolley from the side tracks for a short distance along the main line. This avoids the use of switch plates or similar devices. At some of these junction points the pantograph engages as many as six trolley wires.

The overhead lines are protected from lightning by 2,400 volt D. C. type ME arresters installed on poles at intervals of one-third of a mile the entire length of the system.

Feeders.

The feeder layout with section insulators, switches, etc., is shown in the diagram. The 4-0 trolley is reinforced between the substations with two 500,000 c. m. bare copper cables tapped to the trolley at intervals of 1,000 ft. A 4-0 negative return wire is also installed between Rocker and East Anaconda. This wire is carried on the trolley poles and is connected to the cross bonds at intervals of 1,000 feet. The rails are connected by 4-0 bonds at every joint. The substations are normally connected together by these feeders, allowing an interchange of current. In emergency either station can supply current to the entire system.

Locomotives.

The locomotive equipment consists of seventeen (17) 80-ton units, fifteen for the freight and two for passenger service. The freight locomotives are geared

Overhead Trolley Construction

for slow speed and are operated in pairs for the main line service. The maximum free-running speed is 35 m. p. h.

The two passenger locomotives are of the same construction as the freight units, but are geared for a maximum free-running speed of 55 m. p. h. A speed of 45 m. p h. is made with three passenger coaches on straight level track.

The continuous tractive effort of a single 80-ton freight locomotive is 25,000 lbs. at 15 miles per hour. The maximum tractive effort for a period of five minutes is 48,000 lbs. based on a tractive co-efficient of 30 per cent.

These locomotives are of the articulated double track type with all the weight on drivers. The cab contains an engineer's compartment at each end and a control compartment for control apparatus. This cab is of the box type extending the entire length of the locomotive and is provided with both end and side doors. The entire weight of the locomotive is carried on semi-elliptic springs suitably equalized.

The central channels forming a part of the underframe are enclosed and are utilized as a distributing air duct for the forced ventilation of the motors. The air is conducted through the center pins, which are hollow, into the truck transoms and thence to the motors. The engineer's compartment at either end of the cab contains the operator's seat, controller, air brake valve, bell and whistle ropes, ammeter, air gauges, sanders and other control apparatus within immediate reach of the engineer.

The contractors, reverser and rheostats, which are located in the central portion of the cab, are mounted in two banks running lengthwise of the compartment and are conveniently arranged for cleaning, inspection and repair. All apparatus and circuits carrying 2,400 volts thoroughly protected from accidental contact.

The motors are of the GE-229-A commutating pole type, wound for 1,200 volts and insulated for 2,400 volts. This motor was designed for locomotive service and is provided with forced ventilation. The method of ventilation is similar to the well-known ventilated motors, but the volume of air circulated is increased by the use of an auriliary blower mounted on an extension of the dynamotor shaft. The gear reduction on the freight locomotive is 4.84 and on the passenger locomotive 32. The double unit, 160-ton locomotive is capable of giving a continuous sustained output of 2,100 h.p. The motors are connected to the driving wheels by twin gears similar to those used on the Detroit River Tunnel, Baltimore & Ohio, and the Great Northern locomotives.

The control equipment is Sprague-General Electric Type M, multiple unit, operating the four motors in series and in series-parallel. Two 1,200 volt motors are permanently connected in series. The controller provides ten steps in series and nine in series-parallel. The transition between series and series-parallel is effected without opening the motor circuit, and there is no appreciable reduction in tractive effort during the change. The transfer of circuits at this point is made by a special change-over switch, which is operated electric-pneumatically.

The 2,400 volt contractors are operated from the 600 volt control circuits, and are specially constructed to separate the 2,400 volt parts from the coils and interlocks which carry the 600 volt current. The necessary insulation is obtained by large clearances and by the use of porcelain and mica insulation. The armature is connected to the contact lever by a wooden rod. The contacts, magnetic blowout and arc chutes are also especially designed to rupture the 2,400 volt arc.

Current is collected by overhead roller pantographs, pneumatically operated and controlled from either engineer's compartment by an air valve. A 2,400 volt insulated bus line runs along the center of the cab roof. These bus lines are connected together by couplers between the two freight units, so that current may be obtained from either one or two collectors. The air brakes are the combined straight and automatic type; and the compressor is of the CP-26, 600 volt type, having a piston displacement of 100 cu. ft. of air per minute when pumping against a tank pressure of 135 pounds. Radiating pipes are provided on the roof of the cab for reducing the temperature of the compressed air before it reaches the high pressure cylinder.

Locomotive Data.

Length inside of knuckles	37 ft. 4 in.
Length over cab	31 ft.
Height over cab	12 ft. 10 in.
Height with trolley down	15 ft. 6 in.
Width over all	10 ft.
Total wheel base	26 ft.
Rigid wheel base	8 ft. 8 in.
Track gauge	4 ft. 8½ in.
Total weight	160,000 lbs.
Weight per axle	40,000 lbs.
Wheels, steel tired	46 in.
Journals	6x13 in.
Gears, forged rims, freight locomotives	87 teeth
Gears, forged rims, passenger locomotives	80 teeth
Pinions, forged, freight locomotives	18 teeth
Pinions, forged, passenger locomotives	25 teeth

Tractive effort at 30 per cent coefficient.....48,000 lbs.
Tractive effort at one hour rating.....30,000 lbs.
Tractive effort at continuous rating.....25,000 lbs.

The locomotives have been maintained by the regular shop force with the assistance of one man experienced in electrical apparatus.

Dynamotor for 600 Volt Circuits.

For operating the control equipment and air compressor and for lighting the locomotive and cars, 600 volt current is supplied from the 2,400, 600 volt dynamotor installed on each locomotive. This machine is similar in construction to the 1,200, 600 volt dynamotor, having two distinct sets of armature coils wound on the same core and brought out to a commutator at each end. One of these windings is designed for 1,800 volts and the other for 600 volts, the two commutators being connected in series across the 2,400 volt circuit. The lead current is taken from the 600 volt commutator.

2,400-Volt D. C. Locomotive Employing Four 1,200-Volt Motors in Series and Series Parallel Combination

The mechanical load furnished by the direct connected blower supplies sufficient current in the series field windings to provide for the necessary excitation, so that no shunt windings are required. The blower which supplies ventilating air to the motors consists of a multivane fan mounted on an extension of the dynamotor shaft. It has a capacity of 7,200 cu. ft. per minute at 4 inches pressure.

The principal data and dimension applying to the locomotives are the following:

Lighting The Passenger Coaches.

Standard 600 volt lighting fixtures will be used on the cars, and each passenger and baggage coach will be wired for five groups of five lamps in series. The lights in each car will be controlled by a suitable master switch and fuse with snap switches in the individual circuits. Thirty-six watt railway type Mazda lamps are used, giving about 26 c.p. at 110 volts per lamp. Lighting current will be taken from a 600 volt train line bus, which is connected to the dynamotor on the locomotives.

Electric Hot Air System.

All of the passenger and baggage cars now used between Butte and Anaconda will be heated as well as lighted by electricity as soon as the equipment can be installed. The cars will be heated from a single heating unit installed underneath the car floor and supplied from a 2,400 volt bus connected directly to the 2,400 volt bus on the locomotives. This unit will have a maximum capacity of 25 kw. and will be used to heat the air which is distributed to different parts of the car by means of a small motor driven blower. Cool air will be drawn into the insulated case enclosing the heating units from some point on the roof of the car. After passing over the heating coils the air will be carried through ducts under the floor of the car to radiators placed between alternate seats. The blower has a capacity of from 500 to 1,000 cu. ft. of air per minute, and the motor is connected in series with the heating units.

In order to increase the range of the heating equipment to meet the requirements of varying temperatures, provision is made for connecting the coils to give a total consumption of 10, 15, 17.5, or 25 kw. The temperature of the car is regulated at all times by a thermostat.

All apparatus for the electrification of this road was furnished by the General Electric Company, of Schenectady, N. Y., U. S. A.

Electrification of C. M. & P. S. R. R. Mountain Division

It has been definitely decided to use the 2,400 volt direct current system on the electrification of the Deer Lodge-Three Forks section of the Rocky Mountain division of the Chicago, Milwaukee & Puget Sound R. R. It has also been decided that the transmission voltage will be 100,000 volts, feeding 5 sub-stations, ranging in capacity from 3,000 to 4,000 k.w. depending upon their relative location to heavy grades.

The entire rolling stock will be patterned very closely after that of the Butte, Anaconda & Pacific R. R., which installation was made very largely as an investigation of the high voltage d. c. system by this road. This first section to be electrified contains 113 miles of main line, or the equivalent of 168 miles of single track including sidings and yard tracks. The overhead trolley will be employed and this will be suspended from mast arms on wooden poles on straight track and by span wire construction on wooden poles on the curves. In the yards, containing 4 tracks or more, the overhead bridge type of construction for the trolley will be employed.

Constant Potential Yard Charging Systems

J. R. Sloan and W. H. Keirns

EDITOR'S NOTE—*This article was prepared at the special request of the* 1913 *Convention of the A. R. E. E. as an appendix to the Report of the Committee on Methods of Charging Storage Batteries.*

In response to the desire of the Convention for further information relative to the lay-out of wiring for a yard employing the "Constant Potential" system of charging and the cost of same as compared with the cost of equipping the same yard for the constant current system and typical graphs showing the current taken by a battery charged under constant potential conditions—we beg to submit the following:

In designing the wiring layout the starting point is a study of the train and yard schedule and the yard layout, to determine how long the cars lay over, what time is available for charging; on what tracks the cars will be placed and obtain from this information an approximate idea of the load curve on each section.

Having this load curve and assuming a maximum drop in potential the calculation of the sizes of wire may be made on the assumption that the maximum load is uniformly distributed over the section. The yard bus to which the various feeders are connected may therefore be assumed to be carrying zero current and might therefore be disconnected midway between feeder connections without affecting the distribution of current in the several feeders, and therefore the size of each feeder may be calculated to give the drop assumed.

Due to the shifting of the cars in the yard and the battery current decreasing as the batteries become fully charged it must be recognized that the load conditions are continually changing, but having assumed the maximum condition as above, any change will be a decrease in the current and potential drop in the feeders. The decrease in drop in the potential will mean a greater effective E.M.F. for charging the batteries still connected, but experience has shown that considerable variation of the effective voltage i. e., 2 or 3 volts, does not greatly affect the current taken by any particular battery.

The following is a description of a yard that has been equipped for the so-called "constant potential" scheme of charging; to charge batteries having a nominal voltage of 60.

Fig. 1 is a combination cut showing the yard lay-

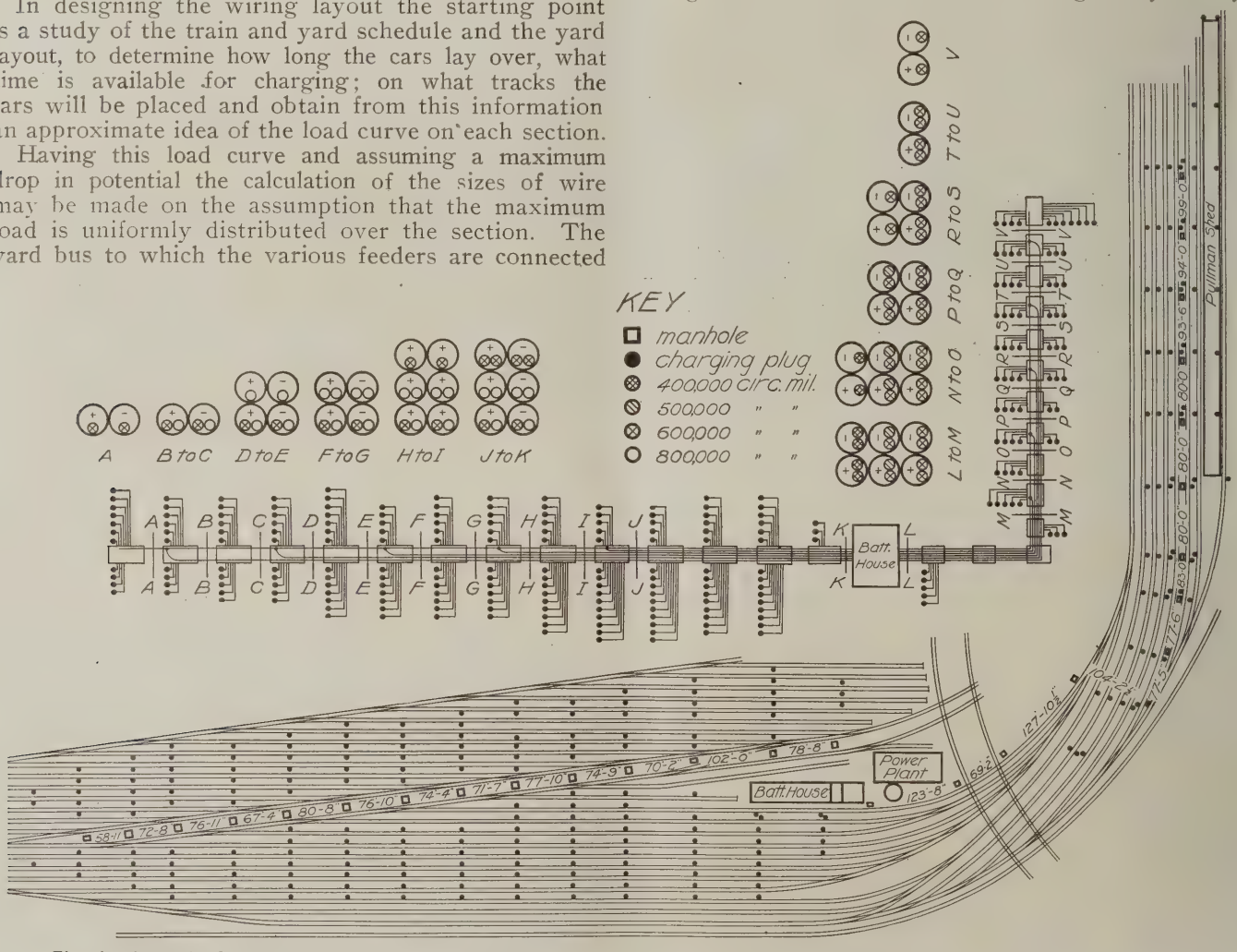


Fig. 1. Layout of Passenger Coach Yards, Showing Location of Manholes and Charging Plugs. Diagram Above Shows Number of Charging Plugs and Sizes of Feeders in Each Circuit

out as well as a wiring diagram of the yard. In this scheme the bus lines and feeders are carried through the center of the yard, along the "ladder track" in the upper yard and between tracks in the lower yard.

These busses and feeders are drawn into 3" fiber ducts laid in concrete, these ducts connecting with manholes located approximately 80 feet apart. The busses and feeders are of good grade of rubber covered wire, taped and braided, without lead covering.

In the manholes is placed a contactor and resist-

ance panel for each line leading to a charging receptacle in yard. The contactor panel contains two 150 amp. N.E.C. fuses and a remote control contactor; the function of this contactor being to short-circuit three resistance grids when it is desired to charge an Edison battery and is operated by a special contact placed in the charging receptacle. The resistance

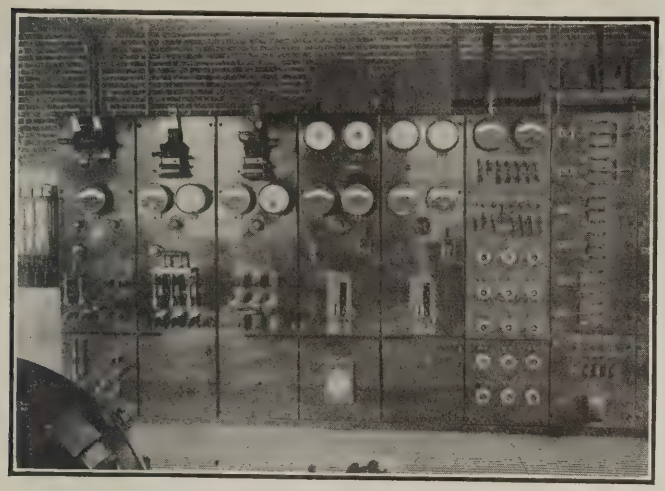


Fig. 2. Switchboard for Supplying Constant Potential to Yard Charging System

panel contains four resistance grids arranged in series and so connected that the contractor will short circuit three grids. Diagram of these connections is shown in Fig. 4.

From these manholes a special three wire cable is run to each Anderson charging receptacle. This cable consists of two No. 2 stranded conductors and one No. 14 solid conductor; wire insulated with a good grade of rubber insulation and wires protected as follows; $\frac{1}{16}$" lead sheath covered with one layer of jute, this in turn covered by two layers of steel ribbon wound in opposite directions and the whole protected by a layer of jute. This cable is laid by simply digging

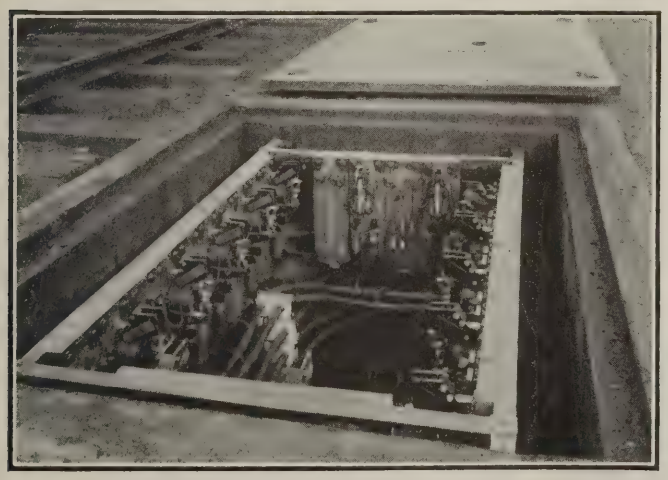


Fig. 3. Manhole Showing Contactors for Making and Breaking Charging Circuit

a trench of sufficient size to accommodate all cables leading from the manhole and then place cables in ditch without any protection other than its own armor. When a point in the yard is reached where a receptacle is to be placed, the cable is carried up through a wood form supporting the cast iron base of the receptacle and the base and cable are then encased in the concrete base. After the concrete has hardened the receptacle proper is applied.

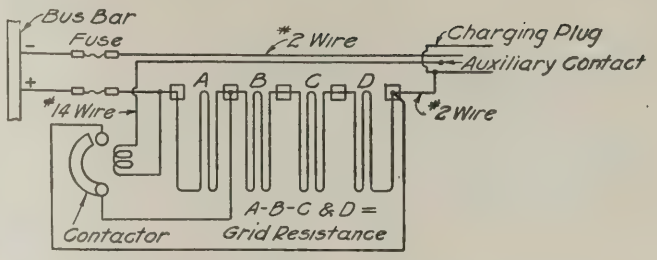


Fig. 4. Wiring Diagram of Contactor Circuit

Fig. 4 shows the design of resistance grid found to be the most satisfactory for general use. This grid is composed of metal known as "Advance Resistance Ribbon." It has a zero temperature co-efficient and can be operated continuously at 900° F., without deterioration. Four of these grids comprise the resistance.

Photograph; Fig. 2 shows the switchboard arrangement in which it will be noted that six panels are all that is required to handle the 248 receptacles connected. Two of these panels are for the control of the a.

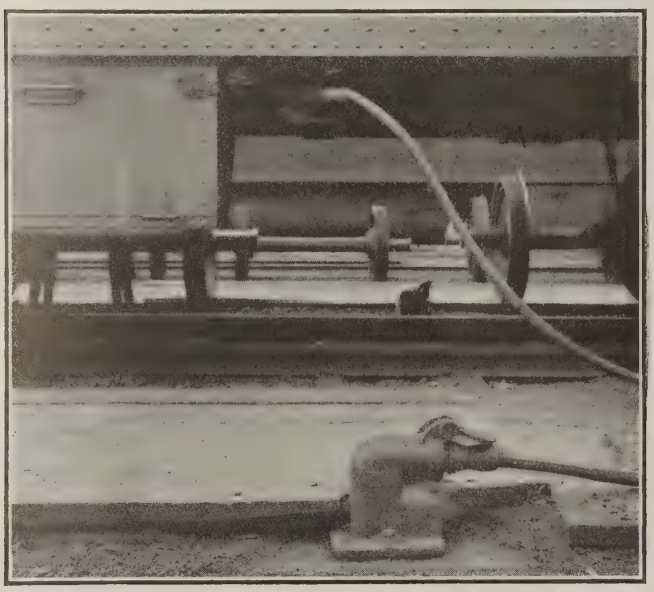


Fig. 5. Charging Plug with Battery on Charge

c. current used on motors. Three panels are for the d.c. current furnished by each generator and one panel is used for charging and discharging batteries while in battery house for cleaning and repairs. This panel is so arranged that the charging and discharging current is controlled by the same rheostat and separate ammeters are provided for showing the charging and discharging rate.

The d.c. portion of the switchboard is provided with two sets of bus bars, one set for each yard. The generator switches are arranged so that either generator can be operated on either set of bus bars, and a tie switch is provided for use when it is desired to operate both yards from one generator. The yard bus and feeders are connected direct to their respective switchboard busses.

Fig. 10 shows a graphic voltmeter chart taken at extreme end of the line under regular operating conditions. The voltage at switchboard being held constant at 94 volts by a Terrill regulator, as shown on Fig. 9.

Fig. 7 shows a typical current chart when charging a fully discharged lead battery through four resistance

grids, and Fig. 8 shows a corresponding chart for Edison batteries charging through one resistance grid.

COMPARISON OF SYSTEMS

Constant Current—Wire		Constant Potential—Wire	
44,030 ft. No. 1 R. C. W.	$ 6,472	5,178 ft. 800,000 C. M., R. C. W.	$4,178
209,439 ft. No. 2 R. C. W.	23,038	11,226 ft. 600,000 C. M., R. C. W.	7,319
89,464 ft. No. 4 R. C. W.	7,426	2,364 ft. 500,000 C. M., R. C. W.	1,267
28,920 ft. No. 4 F. P. W.	879	4,212 ft. 400,000 C. M., R. C. W.	1,920
		11,500 ft. Special No. 3 wire cable	5,175
Charging Receptacles		**Charging Receptacles.**	
248 charging receptacles	$1,612	248 charging receptacles	2,604
		248 contactor panels	3,348
		248 resistance panels	310
Miscellaneous		**Miscellaneous**	
30,702 ft. 3½ in. fibre conduit	$ 1,689	9,440 ft. 3½ in. fibre conduit	$ 519
21 Panel switchboards	11,334	6 Panel switchboard	1,350
3 100 K. W. Motor Gen.	6,450	3 100 K. W. Motor Gen.	6,450
Battery house and Generating Room	16,000	Battery house and Generating Room	13,028
28 Manholes	2,744	28 Manholes	2,744
Racks for manholes	336	Racks for manholes	728
Sewers and drainage	5,489	Sewers and drainage	5,489
Exca. and laying conduit	6,510	Exca. and laying conduit	5,870
Rubber tape	$ 120	Rubber tape	89
Friction tape	20	Friction tape	14
Solder	20	Solder	15
50 Charging cables	950	50 Charging cables	1,050
3% for miscel. supplies	2,733	3% for miscel. supplies	1,980
Labor installing	2,550	Labor installing	2,400
	$ 96,372		$67,847
10% Eng. & Conting.	9,637	10% Eng. & Conting.	6,784
Total	$106,009	Total	$74,631

The following is the statement showing comparison of cost of installing "Constant Current" and "Constant Potential" charging facilities in the above Yard, from which it will be seen that the cost of the constant potential scheme is approximately 70 per cent of the cost of the constant current system to do the same work.

It should further be noted that the "constant potential" scheme is figured on a maximum of five volts drop and the "constant current" scheme on a maximum of 20 per cent and an average drop of 15 per cent.

Were the "constant current" scheme figured for the same drop as the "constant potential", i.e., 5 per cent the cost of the wire would be greatly increased.

The wire costs as below furnish an interesting comparison:

COMPARISON OF WIRE COSTS.

Constant Potential, 5 Per Cent Drop.

5,178 ft. 800,000 C. M.	$ 4,178
11,224 ft. 600,000 C. M.	7,319
2,364 ft. 500,000 C. M.	1,267
4,212 ft. 400,000 C. M.	1,920
11,500 ft. Spec. 3-wire cable	5,175
	$19,859

Constant Current, Drop Max. 20 Volts, Avg. 14 Volts.

44,030 ft. No. 1 R. C. wire	$ 6,472
209,438 ft. No. 2 R. C. wire	23,038
89,444 ft. No. 4 R. C. wire	7,426
28,920 ft. No. 4 F. P. W.	879
	$37,815

Constant Current with 5 Per Cent Drop.

44,030 ft. 300,000 C. M. wire	$14,423
96,232 ft. 250,000 C. M. wire	31,660
63,354 ft. 4/0 wire	16,979
49,582 ft. 3/0 wire	11,466
39,626 ft. 2/0 wire	7,787
18,350 ft. 1/0 wire	3,101

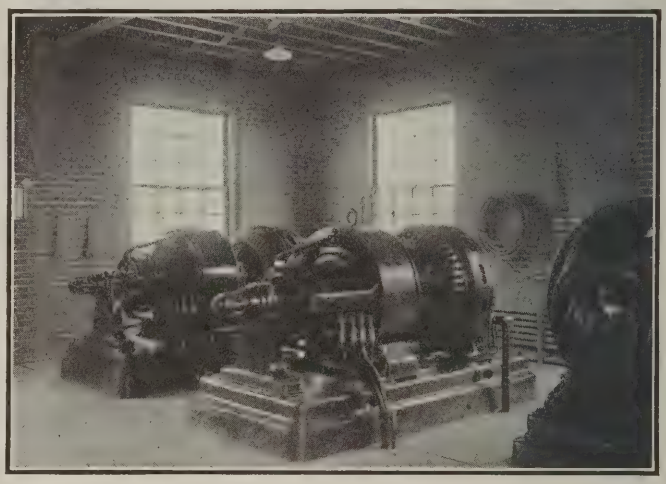


Fig. 6. Interior of Sub-Station, Showing Motor Generator Sets

12,150 ft. No. 1 wire	1,786
10,050 ft. No. 2 wire	1,106
9,270 ft. No. 4 wire	771
28,920 ft. No. 4 FP. wire	879
	$91,958

The high cost of copper to wire a yard, similar to the illustration, for constant current charging with five per

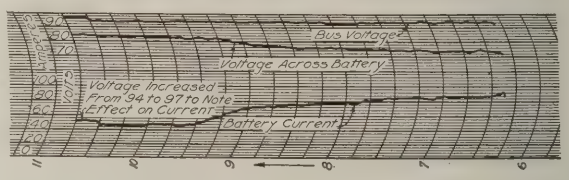


Fig. 7. Recording Meter Curves, Showing Voltage and Current on Charge for a Lead Battery

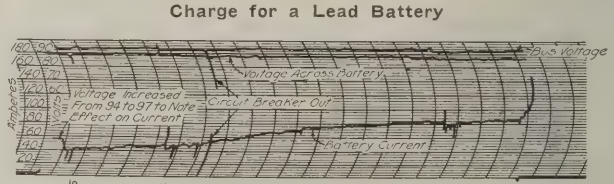


Fig. 8. Recording Meter Curves, Showing Voltage and Current on Charge for an Edison Battery

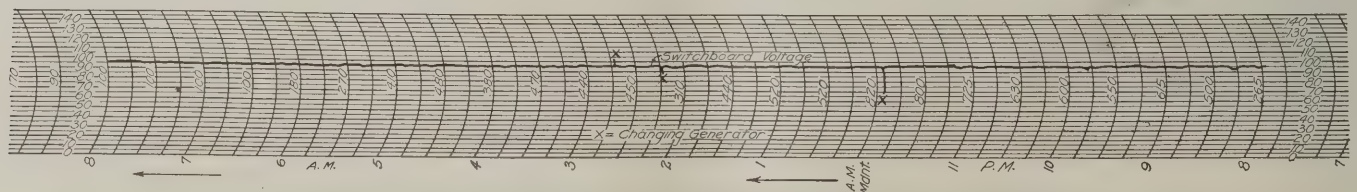


Fig. 9. Recording Voltmeter Curve, Showing the Voltage at the Switchboard

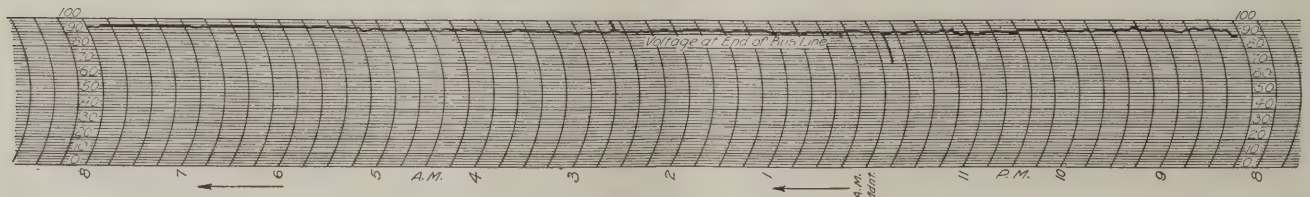


Fig. 10. Recording Meter Curve, Showing Voltage at the End of the Bus Line. Loads Are the Same as Those Given on Curve Fig. 9

cent line loss would make the proposition prohibitive and if yard was wired for constant current charging, smaller wire with greater line loss would no doubt be adopted.

In order to compare this wire loss in the two systems we will assume that 240 ampere hours are given to 50 cars each day.

For constant potential we would have 240 x 95 x 50 equals 1,140 k.w. hours per day.

For constant current we would have 240 x 110 x 50 equals 1,320 k.w. hours per day or a difference of 54,000 k.w. hours per yard of 300 charging days. This current at 2c rate would cost $180.00, which is 5 per cent of $21,600.00 and based on operating costs one could therefore afford this amount over and above the amount required for the constant current scheme in order to obtain the constant potential scheme.

Although we are opposed to the principle of charging batteries in series that are discharged in parallel, for the reason that as a rule the state of charge of the batteries when connected to the source of power will probably vary widely, still if conditions of operation are such that on discharge the same current demand is made on each battery, we can see no objection to this method.

The switchboard, as shown on the accompanying cut, Fig. 9, has been worked out for a service where this condition obtains. Two cars only will be on charge at one time and these two cars will have their batteries connected in series through the board.

Electric Headlight Tests

J. G. Scrugham

Since the safety of the traveling public and of men engaged in the transportation industry is in a certain measure dependent upon the use of a proper headlight for cars or locomotives, it seems proper to discuss this important subject at an Industrial Safety Conference. Twenty-eight states have adopted legislation embodying seventeen different specific laws regarding the use of headlights on locomotives. The enlightened state of Georgia requires a 300 watt arc lamp with a 23 in. reflector, while in the adjacent state of Mississippi, an 18 in. reflector is deemed necessary. In South Carolina the light must measure 10,000 candlepower with a reflector. Nebraska requires a light that is sufficiently strong to distinguish an object the size of a man at a distance of 600 ft. (Whether the man is to be a white man or a black man, dressed in white or black clothes, etc., is not specified.) In five states a similar law is enacted in which the distance is set at 800 ft. In Iowa it is made to specify discernment of a man lying down at a distance of 1,100 ft. Several states require a light of 1,500 candlepower without a reflector. While Wisconsin requires 1,500 candlepower with the reflector. It will be noted that many of the above laws are of a conflicting character, especially as the strongest practicable headlight manufactured at present delivers less than 1,000 mean spherical candlepower without a reflector.

What the traveling public, railroad management, and employes all want is that light which is most conducive to the safe operation of trains. The problem is how to obtain it. The efficiency of a headlight is primarily dependent on the reflector or lens used, and, secondarily on the volume or power of the light itself. The reflector may multiply the horizontal candlepower of the head lamp anywhere from unity to 2,000 times more, depending upon the condition of reflector and the focus used. For example, a 500 horizontal candlepower arc with a dirty, ill focused reflector, may give only a very few thousand candlepower ahead on the track, while a well designed 100 candlepower incandescent, with a properly focused reflector is capable of delivering nearly a quarter of a million candlepower where it is needed. To obtain efficient results it is necessary for the light source to be well concentrated and placed at what is known as the focal point of the reflector. The complaint about poor headlights arises as much from the improper condition of the reflector and focusing, as from the insufficiency of the light itself. There seems to be an almost unanimous opinion that the light reflected ahead should be of sufficient volume to enable the engineer to discern any serious obstruction or fault on the track in time to prevent or minimize the danger of an accident. This means that the object must become visible at a distance of from 500 to 1,000 ft. under ordinary operating conditions. Another requirement is that the light should not be so strong and dazzling as to blind observers or approaching enginemen. A very powerful arc, especially those rich in greenish rays, should be avoided because of the tendency to give a false color to the red danger signals and the injury to the eyes of those looking into its field.

The light should be uniform, reliable, and easily replaced or repaired in case of failure. Our problem is to determine which light most nearly fulfills these conditions. In recent years the unit, called the candlepower, has been practically abandoned by illumination engineers and lamp manufacturers on account of its ambiguity. The most definite and useful unit is called the foot candle, and is a measure of the illumination on the objects to be made visible, instead of being a measure of the light source itself. To those having normal vision, an illumination of one-tenth of a candle foot thrown from a headlight on a dark object the size of a man renders it distinctly visible at a distance of a thousand feet or more under ordinary conditions. A man wearing white clothes can be discerned at twice the distance. If he wears some glittering jewelry, as in one case which came under my observation, he can be spotted more than half a mile away. However, all trials should be based on discernment of dark objects, as the average trespasser on the right of way is rarely so accommodating as to display his jewelry to the engineer on the approaching train.

Illumination such as I have just described can readily be obtained from a concentrated filament lamp of 100 spherical candlepower if a well silvered parabolic reflector is used. In my opinion any stronger illumination is a waste of light. In foggy weather or when the air is filled with snow flakes, the lower can-

*Paper presented at the "Safety First" Conference at Reno, Nevada. Jan. 26, 1914.

dlepower lamp again has the advantage as the rays are more penetrating than those of the higher candlepower light. These latter are reflected back toward the observer. It is only within the past few months that a satisfactory incandescent lamp has been developed for headlight purposes. The old carbon filament lamp and the earlier forms of tungsten lamp were of such nature that the light source could not be sufficiently concentrated to give good results with a parabolic reflector. However, the development of the wire drawn helix filament tungsten lamp surrounded by nitrogen gas seems to have solved the problem. When a lamp is so constructed that practically all of the light source can be placed at the focal point, the illuminating efficiency is vastly higher than when the light covers a large area. For this reason a low candlepower lamp can frequently reflect a better light on the track than the large arc. The big headlight manufacturing concerns, such as the Pyle, Remy, and others, who formerly specialized in arcs are now building turbo-generator sets to accommodate the rapidly increasing demand for the incandescent light. The advantages of giving no fumes to blacken or tarnish a reflector and requiring no elaborate mechanism for adjustment is obvious to all. I hold no brief for any particular make or type of generating apparatus. The point I do wish to make is that a five hundred or a five thousand candlepower light is of very little use in preserving the lives of the traveling public unless it is properly reflected and directed to where it is needed. Another thing worthy of consideration is the location of the light on the front of the engine.

For many reasons it would be a marked advantage to have the headlight located lower down on the front of the boiler than is the present practice. I was formerly a very warm advocate of such a change, but after observing the ultra-coarse methods used by an Austrian helper, in opening up a smoke box door with a sledge hammer, the desirability of the present headlight location became obvious.

Record of Tests.

The following summary of distance tests made with headlights, February 5, 1913:

Acetylene Standing Test.

Date	No. of men on track	As obstacle	Counted Ft.	Remarks.
7-26-11	1	799		
"	1		524	
"	1		734	
"	1		681	
"	1		563	
"	1		642	
	Average	799	642	
10-25-10	4	742		Commercial Acetylene Co. gas and reflector
"	4	768		
"	4	787		
"	1	831		
"	1	697		
	Average	765		
9-2-10	5	449		Commercial Acetylene gas and reflector.
"	5	481		
"	1	441		
	Average	457		
9-2-10	6	513		Commercial Acetylene reflector and S. P. generator.
"	6	597		
"	1	469		
	Average	526		
9-2-10	4	637		Commercial Acetylene reflector, S. P. Co.
"	4	645		
"	4	725		
"	4	705		
	Average	692		
9-2-10	5	637		Commercial Acetylene Co. reflector and S. P. generator.
"	1	661		Commercial Acetylene Co. gas and S. P. Co. reflector.
"	4	773		
"	4	773		
	Average	736		

Acetylene Running Test.

10-25-10	4	601	Commercial Acetylene Co. 6-in. reflector.
"	4	653	Commercial Acetylene Co. 6-in. reflector.
	Average	627	

Electric Incandescent, Standing Tests.

7-8-12	2	1057		Mazda light from General Electric Co.
"	1	1030		Mazda light from General Electric Co.
"	1	1030		Mazda light from General Electric Co.
"	2		960	Mazda light from General Electric Co.
"	3		960	Mazda light from General Electric Co.
"	3		960	Mazda light from General Electric Co.
9-11-12	2	674		Westinghouse zigzag filament.
"	2	674		Westinghouse zigzag filament.
"	2	674		Westinghouse zigzag filament.
"	1		590	Westinghouse zigzag filament.
"	2		640	Westinghouse zigzag filament.
9-11-12	2	780		Westinghouse U-shaped filament.
"	3	705		Westinghouse U-shaped filament.
"	1		690	Westinghouse U-shaped filament.

Running Tests.

7-8-12	2	990	Mazda light from General Electric Company.
"	1	852	Mazda light from General Electric Company.
9-11-12	3	621	Westinghouse zigzag filament.
"	2	780	Westinghouse zigzag filament.
"	1	690	Westinghouse zigzag filament.
"	3	705	Westinghouse zigzag filament.

Electric Arc, Standing Test.

Date.	No. of men on track visible as obstacles.	No. of men on track counted.	Distance, ft. No. 1.	Distance, ft. No. 2.	Remarks.
8-2-12		1	1067	1217	No. 1 Lacy light.
"		1	1109	1137	No. 2 Pyle light.
"		1	1148	1073	
	Average		1108	1142	
8-2-12	1		1608	1617	
"	1		1568	1561	
"	1			1601	
	Average		1588	1593	

Date.	No. of men.	As obstacle.	Counted.	Remarks.
8-2-11	1	1420		Lacy headlight.
"	1	871		Lacy headlight.
	Average	1146		Lacy headlight.
8-2-11	1	1041		Pyle headlight.
"	2	1169		Pyle headlight.
	Average	1105		

The last two tests are electric arc running tests.

Summary.

	Feet.
Acetylene standing test	653
Acetylene running test	621
Acetylene, all tests	650
Electric arc standing test	1281
Electric arc running test	1125
Electric incandescent, General Electric Co. Standing test	1000
Electric incandescent, General Electric Co., running test	921
Electric incandescent, Westinghouse zigzag filament, standing test	650
Electric incandescent, Westinghouse zigzag filament, running test	621
Electric incandescent, Westinghouse U-shaped filament, standing test	725
Electric incandescent, Westinghouse U-shaped filament, running test	725

In test of Westinghouse incandescent the zigzag filament light tested had been in service 55 hours of light; the U-shaped filament tried was new.

In these tests the persons on the track were dressed in dark clothes. The column headed "as an obstacle" shows distance persons were visible as an obstruction of some kind on the track. The column headed "counted" shows distance when the number of persons on the track could be counted from the cab or discerned as a person.

Relative to oil light, we have no tests made under the same conditions as above.

A test made at Benali in 1907 noting the distance another engine (without lights) could be seen gave the relative distance for oil and acetylene as 1 to 2.18.

On this basis one or more people would be vis-

ible on the track with an oil light at a distance of 300 ft.

General comparison as follows using the standing test and in the incandescent light the higher candlepower, General Electric only:

	Feet.	Relative Distance.
Oil light	300	1.00
Acetylene	653	2.18
Electric incandescent	1,000	3.33
Electric arc	1,281	4.27

Engine 3017—Aug. 8, 1913.

This lamp is a General Electric Incandescent Tungsten having nitrogen in bulb. It is operated by Exide Storage batteries made by Electric Storage Battery Company.

Batteries arranged 2 sets in multiple 4 batteries in series in each set, a rheostat is used and the circuit shows 8 volts and 12 amperes, 6 volts across the lamp which consumes 72 watts and is rated at about 100 candlepower.

Test was made of light on Sacramento Southern on morning of August 7th, between hours of 1 and 3:30 a. m. Night clear and dark; moon absent; men on track dressed in dark clothes.

Globe tested had been in service approximately 5 hours, light being applied at Oakland August 6th for run Oakland to Sacramento, train No. 16.

Result of distance tests as follows:

Men on Track Discerned as Object or Obstruction of Some Kind.

No. of test.	No. of men on track.	Distance, ft.
1	3	1,099
2	3	993
3	3	1,079
	Average	1,057
	No. of men on track counted.	
1	1	857
2	2	751
3	1	917
	Average	842

Running Test—Engineer and Fireman Only Taking Part—Distance Men on Track Discovered as an Object or Obstruction of Some Kind.

No. of test.	No. of men on track.	Distance, ft.
1	3	791
2	2	766
3	2	1,038
	Average	865

Pyle National Incandescent Headlight—November 15, 1913.

This generator (Type "S" Turbo-Generator Unit) has been installed for trial on engine No. 2328, furnishing current for a 20 watt 32 volt Westinghouse Mazda incandescent headlight lamp.

Roundhouse Test of Type "S" Generator.

Test.	Steam pressure.	Revs.	Volts.	Headlight, amps.	Watts.	Auxiliary lights, cab and markers.	Approx. total watts.	Steam, per hr., lb.	Steam, per kw. hr., lb.
1	198	3,642	30.7	3⅛	96	5	255	106	416
2	198	3,578	30.5	3	91.5	None	91.5	90	984
3	198	3,727	29.0	00	00.0	None	00.0	74	...
4	198	3,549	29.5	3	88.5	4—1	328	119	363

In test No. 4 one of the Westinghouse headlight lamps was put in place of one of the Marker lights in order to note operation of generator with a little overload.

Steam used per hour by type "S" in operating headlight alone in comparison with type "C" which is most in use and with the later compound wound type "E" as follows:

Steam lb. used per hour.	
Type "S" ..... 90 lb.	Test above.
Type "E" ..... 215 lb.	Test by Pyle Co.
Type "C" ..... 421 lb.	Test report of Dec. 16, 1912.

The type "S" turbo-generator is a small compact unit, its weight compared with types "E" and "C" as follows: Type "S," 125 lb.; type "E," 290 lb.; type "C," 350 lb.

It operates satisfactorily in round house test and in road service is easy to regulate and entirely closed in and protected from sand and dirt and appears to be a satisfactory generator for the low current required by the tungsten incandescent lights.

Distance test of the 120 watt 32 volt incandescent used in above test was reported September 30, 1913, as follows: Three men on track observed as obstruction of some kind, 1,149 ft.; 1 to 3 men on track counted from cab, 854 ft. Running test, approximately 30 m.p.h., 3 men on track observed as obstruction of some kind 976 ft.

Reverting to the subject of headlight legislation again. While the startling originality of the ideas of some of the bill framers might be deemed commendable, yet the question is obviously one that should receive the attention of some competent Federal Commission, empowered to make recommendations to congress. Such a commission should consist of a number of locomotive engineers and other qualified experts who would determine what degree of illumination on an object expressed in foot candles is required for the engineer with normal vision to sight a man in dark clothes at various specified distances. All legislation should be based on such accurate and reliable information instead of in haphazard manner as at present.

Electrification of the London & North-Western Suburban Lines

Rapid progress is being made with the electrification of the suburban lines of the London and North-Western Railway. Although the entire zone to be electrified is far from completion, a certain section is already operated electrically, there being 4 trains of 3 coaches each, although at present largely experimental, operating over a small section of the line. Provision has been made for the purchase of current from the local central station until the completion of the main generating plant of the electrified zone. This generating plant will include 5 turbine-driven, 3-phase alternators having an aggregate normal full load capacity of 25,000 kw. and capable of developing 31,000 kw. at the 2-hour overload rating. Current will be generated at 11,000 volts and a frequency of 25 cycles per second.

There will be 10 sub-stations provided, each including three 6-phase rotary converters and 9 single-phase static transformers. A large storage battery and automatic reversible booster will also be installed in each sub-station. The sizes of converting units are to be 750 and 1,000 kw., with a large over-load capacity and the machines are of the latest self-synchronizing type. It is anticipated that the generating station and substations will be ready for use about the end of the present year.

The company are very carefully considering the question of experimenting on a section of line with a system of electric cab signalling for electric trains with the view to increasing safety and expediting traffic. All cars to be operated on the electrified zone will be electrically lighted and heated. The entire electrification is being carried out under the supervision of Mr. F. A. Cortez Leigh, electrical engineer of the London & North-Western Railway.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

Lesson No. 10--Question Box

1.—Should vent holes be in dry cells, and if so, why?

Vent holes should never be in dry cells. Were this the case the moisture of the electrolyte would evaporate and there would be practically no action between the elements and the dry mixture.

2.—Does the external resistance, when low, need a small amount of current from the cell and, when high, a greater supply of current to pass that resistance in order to do the required amount of work?

This depends entirely upon the circuits itself and the apparatus connected in it, whether a large or small amount of current is required.

3.—Are the rough lumps of copper which form on the negative element of the gravity cell caused by hydrogen gas?

The lumps of copper which form on the negative element are not caused by hydrogen gas, but by chemical action which takes place between the copper and copper sulphate and zinc sulphate.

4.—Is the word "oxide" connected in any way with oxidation? In what way is zinc oxide in the gravity cell connected with the zinc oxide plate in the BSCO and Gordon cells?

All oxides are produced by oxidation, which is a chemical process. The zinc oxide which is formed in the gravity cell is of the same chemical composition as the zinc oxide formed in the caustic soda cells.

5.—A gravity cell, set up about three weeks, has plenty of bluestone (covers the copper), plenty of water and a clear color, but on the zinc is a thin layer of the "dark brown mud." Being a new battery, would you attribute that formation to chemical action—the oxidation of the zinc in its earliest state—or that this battery has not enough work?

The dark brown deposit on the zinc is copper from the decomposed copper sulphate solution, and is probably caused by the cell not being used enough to prevent the chemical reaction which produces it when the blue solution comes in contact with the zinc electrode.

6.—Could the zinc solution also be called the zinc electrode and the same with the copper solution?

The zinc solution is not the same as the zinc electrode, nor is the copper solution the same as the copper electrode. They should not be confused.

7.—At times there is a collection of bubbles on the positive element or zinc; is that also caused by hydrogen gas?

The bubbles on the electrodes of the gravity cell are caused by chemical reaction and are hydrogen gas.

8.—Why is the zinc the negative electrode in the Clark cell, when, according to the table given on page 4, E-1, it should be the positive?

In the description of this cell, Lesson 4, it will be noted that different solutions are used with the two electrodes. In the table of elements arranged in order from positive to negative, they are given in the order which is most common, and it also stated that their order is different in different electrolytes.

9.—In the equation $\frac{E-V}{I}$ for finding the internal resistance of a cell or battery, it is stated that the E equals the voltage on open circuit and V on closed circuit when it is furnishing the current. Does a battery have any voltage on open circuit? Is it not necessary to connect the poles of the battery to produce a current? If this open circuit voltage means the short-circuit voltage, how is it ascertained?

A battery which has no open circuit voltage is of absolutely no value as a current generator. In order to determine what this voltage is, there would, of course, be a connection through a voltmeter between the two terminals of the cell or battery. It might be added that the voltmeter has very high resistance windings, which would possibly answer the question relative to the connection between the poles of the battery. The resistance of the voltmeter is so great that no appreciable current would pass through it. It is necessary to connect between the poles of the battery to produce current. An ammeter would be connected in the circuit to measure the current flowing and the voltmeter would be connected across the battery at the same time.

10.—In the pamphlet E-1, it is stated that a short-circuit test of dry battery shows 12 to 20 amperes, and the voltage, 1.5. This indicates a lower internal resistance of this battery than that of a gravity cell. Inasmuch as the absorbent material in the dry battery is mixed with the electrolyte, it appears that this cell should have a higher internal resistance than the gravity cell, on account of this absorbent material interfering with the flow of current through the electrolyte. Is the resistance offered by the absorbent material entirely neutralized by the depolarizer used?

The construction of a dry battery and the cause of its internal resistance should not be confused, because of the fact that there is a certain solid substance used in the make-up of this cell as compared with the gravity cell. The fact that a solid substance was added to the electrolyte which would change the density of the compound does not necessarily increase the internal resistance, as copper itself is much denser than any material used in the construction of a dry cell, and it has a much lower resistance than any of the materials referred to, or even than the ordinary liquids. The resistance of this cell depends upon its condition and the materials used. The resistance of one part of a circuit, such as the absorbent material in the cell, cannot be neutralized by the resistance of another part of the circuit. This resistance is accumulative, meaning that it is continually increasing, instead of one part neutralizing another.

11.—In the assembly of the Edison R. R. cell there are three terminals shown, two apparently being the copper terminals and the central one being the zinc terminal, instead of only two terminals. How is this battery connected?

The Edison R. R. cell, shown in our pamphlet on Primary Cells, is connected by using the center lug as the zinc or negative terminal and either of the other binding posts as the positive terminal, depending upon which is more convenient.

12.—A new track battery became weak. The bluestone was found hard and compact in bottom of the cell and it required great care to loosen it without fracturing the jar. No old solution had been used in its renewal. The track circuit is extremely short and but one train a day passes over it. Is this caused by faulty material?

This is probably caused by using too small particles of the copper sulphate. It is in reality a crystallization effect, which is caused by much the same process as that of sugar or salt crystallizing in a solid mass. The composition of the bluestone is not changed, but merely its form, as stated in the pamphlet, and

small particles such as dust and pieces smaller than a pea should not be used.

13.—Why is a large number of cells more desirable than a dynamo for generating current? In actual practice this is reversed. Both telegraph companies and railroads are now using the second system. Explain why?

This depends very largely upon the local conditions and is a subject for study for each particular installation. If the telegraph or telephone company has a small station or exchange at some distant point where they cannot readily obtain power, it will be found that they almost invariably use the primary cells. Where lighting current is available all day, motor generators or dynamotors are often used together with storage batteries.

14.—What is the proper amount of solution from an old gravity cell to use in starting a new one?

The colorless solution in a gravity cell should not come lower than about midway between the zinc and copper plates, so that this would determine the amount of the colorless solution which should be used from an old gravity cell.

15.—Why is carbon used in a dry cell instead of a bar of copper?

Copper is not used in dry cells for these reasons: on account of its high cost, liability of corrosion, certain chemical action which would take place when the cell is not being used, and higher voltage obtained from the use of zinc with carbon.

16.—What makes the bluestone in a gravity cell sometimes cake or freeze together?

This is brought about the same as caking of sugar or salt in the bottom of a jar after it stands for a short time, even though covered with water; it is a crystallization effect. The chemical composition of the copper sulphate, when in this condition, is the same as when it is in lumps. This can be avoided by using lumps of proper size as stated in the pamphlet E-1.

17.—Why does scale form on the zinc electrode when the battery short-circuited and none forms when it is discharged through a resistance?

The cause is the very rapid chemical action which would take place when the cell is short-circuited, producing a comparatively large current. The heating effect would tend to cause this formation of the scale.

18.—In the solution of problem 23, pamphlet E-1, the result shows that the battery would last 1,778 days. Would this battery, in actual practice, be effective anywhere near as long as this? Would this battery not deteriorate on account of local action, and how soon?

The total life of this cell would depend largely upon the type of it and the conditions under which it was operated. Theoretically, it would last 1,778 days, or about five years. This would hardly be an economical installation, as an inspection at intervals is necessary, and a smaller ampere-hour cell would probably be as satisfactory and at least cost less for the first installation. If the elements were properly constructed of pure materials, there would be no local action, but, on account of the commercial product often containing slight impurities, probably the plates would deteriorate before the end of the 1,778 days as mentioned.

19.—What kind of mechanism is referred to in E-1, where the method of determining the relative working values of dry cells is discussed?

This is a special device operated by a clock mechanism which, at regular intervals, automatically opens and closes the circuit on which the batteries are being tested. This device is only used at General Office or Division Headquarters, where they would have occasion to test the different kinds of batteries. The description of this device is to warn students against depending entirely upon a test made by the dealer, who merely connects a pocket measuring instrument across the terminals to tell whether or not it is a good cell. The length of time for which the battery will furnish current at a given voltage under these machine-test conditions in the measure of the relative merits of different makes of dry cells.

20.—In pamphlet E-2, problems six and seven show a greater current for 110 than for 220 volts on the same conductor of same gauge and resistance. Explain why this is? What keeps the current down and reduces it while the voltage is increased?

It is stated in this pamphlet that the number of watts or power is the product of current and voltage. Then, for a given number of watts or kilowatts on a 110 volt circuit, the current would be twice as great as on a 220 volt circuit. This increased current for the lower voltage is accounted for by a reduction in the resistance of the windings of the apparatus or other parts at the customer's station, in order to operate at the lower voltage. It is the increased resistance in the customer's equipment which reduces the current when the voltage is increased.

21.—Does a two-wire transmission line consist of one wire carrying current from the power house and the other wire a return, metallic circuit, or do the two wires carry current from the power house with a ground return?

When a transmission line is of two wires—that is, a metallic circuit, one wire may be considered as carrying the current from the source of energy to the customer and the other wire as returning it to the starting point, or power house. If the ground were used as a return conductor, the circuit would be a ground return circuit, and only one wire would be necessary.

22.—(*a*) The "copper loss" in a line is 36,000 watts, and there are four customers on this circuit, each consuming 3,000 watts; would the 3,000 watts consumed by each of them be included in the 36,000 and be considered as consumed by the conductors, or would this be additional power to be furnished by the power house?

(*b*) If the voltage of the circuit was increased from 600 to 1,200 volts with 60 amperes and the line resistance 20 ohms, would this increase in voltage burn out the apparatus if the wiring was of proper size to carry 60 amperes?

(*c*) Then, is it the increase in current and not voltage which would cause this trouble if the wire was of correct size to carry current?

(*d*) Does 36,000 watts represent the power from power house to run the circuit?

(*a*) The line loss is 36,000 watts, which does not include the power furnished to the customers, but is merely that loss in the line transmission which is caused by certain current furnished through a certain resistance. The additional power for the customers would necessarily be furnished at the power house.

(*b*) The line loss in any transmission line may be reduced by increasing the voltage so that a smaller current is furnished, or by increasing the amount of copper in the line which will, of course, reduce the resistance. The higher voltage is preferable providing the apparatus in the circuit is designed for it, otherwise the apparatus in the circuit would be burned out. The line loss is dependent upon the current through the conductor and not upon the voltage at the power house or at the customer's end of the circuit.

(*c*) The current and the resistance are the factors to be considered in heating.

(*d*) 36,000 watts is that amount of power which must be generated by the power house in addition to that which is supplied the customer and represents an absolute loss in the plant.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

At the February meeting of the Railroad Electricians' club it was decided to begin a review of the lessons of the A. B. C. car lighting course, beginning with our March meeting, in which all the various systems of car lighting would be taken up and studied in about the order in which they were given in the car lighting course.

We feel, however, that the line of work already started in this department, in which problems similar to those of the Pennsylvania R. R. Course inElectricity are asked and answered is of value to the men studying this course, and accordingly, this feature of this department will be continued in the *Railway Electrical Engineer.*

Any special features such as "Practical Stunts" or "Questions" brought up at the meeting will be given under "Practical Stunts" and the "Question Box" departments in the following issue.

Problems

Third Lesson—Primary Batteries.

Ques. No. 66. Supposing one of the gravity cells in the battery goes bad and the only thing you have to replace it with is a Gordon cell, what plate of the Gordon cell would you connect in place of the zinc plate of the gravity cell?

Ans. 66. The zinc plate of the Gordon cell should be connected in place of the zinc plate of the gravity cell.

Ques. No. 67. Which plate would you connect of an Edison cell in place of the zinc of the gravity cell?

Ans. 67. The zinc plate of an Edison cell should be connected in place of the zinc plate of the gravity cell.

Ques. No. 68. Supposing it was necessary to replace one dry cell in a battery of cells with an Edison or a Gordon cell, what plate would you connect in place of the zinc plate of the dry cell?

Ans. 68. The zinc plate of the Edison or Gordon cells should be connected in place of the zinc pole of the dry cell. It is thus seen that whenever a cell of any other type is placed in the battery the zinc pole is always connected the same as the zinc pole of the original cell.

Ques. No. 69. Why are not gravity cells used in signal work or outside telephone or telegraph work or any other electrical devices exposed to cold weather in the winter time?

Ans. 69. Gravity cells are not used in signal work or outside telephone or telegraph work for the reason that in extreme cold weather the electrolyte, consisting of copper sulphate at the bottom and zinc sulphate at the top, would freeze and burst the cell jars.

Ques. No. 70. Under what conditions would it be necessary to connect Gordon cells in parallel, and what conditions for the Edison cell?

Ans. 70. Edison and Gordon cells give approximately 30 amperes on direct short circuit, but the cell voltage on short circuit would be very low. In determining whether cells should be connected in parallel, the voltage required must be considered. For ordinary work, however, where the current is over 10 amperes, Edison or Gordon cells should be connected in parallel.

Ques. No. 71. We have a certain battery consisting of 20 cells connected in series of a rated capacity of 200 ampere hours. The voltage available from each cell is .75 of a volt. the external resistance of each cell is .005 ohms and there is an external resistance of 100 ohms in the circuit. This circuit is closed 10 hours each day, how long will the battery last under these conditions, assuming it was new and in first-class condition at the start?

Ans. 71. If the internal resistance of each cell is .05 ohms, the resistance of the 20 cells in series will be (20 x .05) or one ohm, with 100 ohms resistance in the external resistance and 1 ohm internal resistance of the battery, the total resistance is 101 ohms. If a voltage of .75 volts is available from each cell, .20 cells in series would give a total of 15 volts.

Fifteen volts then, with 101 ohms resistance in circuit, would cause (15 divided by 101, or) .14 of an ampere to flow through the circuit. This current being used for 10 hours per day would give a total of (10 x .14) or 1.4 ampere hours per day. If the battery is of 200 ampere hour capacity it will last (200 divided by 1.4) or 143 days.

Fourth Lesson.

Ques. No. 72. We have another circuit having 16 cells in series of a rated capacity of 400 ampere hours connected with a resistance of 75 ohms. The voltage per cell and the resistance of the cells are the same as in problem 71 and the circuit is closed approximately 4 hours per day. How long will the battery last?

Ans. 72. 16 cells in series would have an internal resistance of (16 x .05 ohms) or .8 of an ohm. 75 ohms in the external circuit, and .8 of an ohm internal battery resistance to the total resistance of the circuit, would be 75.8 ohms. At .75 volts per cell, 16 cells would give a total of 12 volts. 12 volts with 75.8 ohms in circuit would give a total of .16 amperes. This current at 4 hours per day would amount to .6 of an ampere hour per day. Since the total capacity of the battery is 400 ampere hours, and only .6 ampere hours are taken out daily, the battery will last 670 days.

Ques. No. 74. Suppose that it is desired to renew a certain battery installation once every six months and that in order to be as economical as possible, we will use the smallest size battery suitable for the work. The circuit requires 3 amperes at 6 volts and operates approximately 2 hours per day. If the cells used are capable of furnishing current at .65 of a volt per cell, (A) what number of cells should be connected in series, (B) what capacity in ampere hours per cell would be advisable to install, (C) how should they be connected, (D) show sketch of connections which should be made.

Ans. 74. Gravity cells should not be worked over ¼ of an ampere. So if this current was to be furnished by gravity cells it would require a parallel connection of 12 cells, but since we want to use the "smallest size battery suitable for the work," we will undoubtedly use an Edison or a Gordon cell, as it will not be necessary to connect these cells in parallel in order to furnish the 3 amperes current required. (A) If the cells are capable of delivering .65 of a volt per cell each, it will require (6 divided by .65) or 9.2 cells to furnish this voltage; in other words, 9 cells would deliver 5.9 volts. (B) A current of 3 amperes in use for 2 hours per day would consume (2 x 3) or 6 ampere hours' capacity per day; in 6 months there are (30 x 6) or 180 days, and since a daily discharge of 6 ampere hours is required, the total capacity of the battery must be (6 x 180) or 1080 ampere hours capacity; (C) 9 cells of the battery should be

connected all in series. Since the capacity of the new Edison cell is approximately 400 ampere hours, it will require that 45 of these cells be connected in 9 sets in series of 3 cells each.

Fifth Lesson.

Ques. No. 75. If 10 Edison B. S. C. O. cells of a 250 ampere hour rating are connected in series and discharged at the rate of .3 of an ampere continuously, how long will the cells last?

Ans. 75. It does not matter how many cells are connected in series, the ampere hour discharge would be the same provided the same current flows through each cell. .3 of an ampere current flowing for 24 hours per day would consume (.3 x 24 or) 7.2 ampere hours daily of the total battery capacity. The 250 ampere hour capacity of the battery would then last (250 divided by 7.2 or) 25 days.

Ques. No. 76. Supposing the cells of problem No. 75 had been connected, 5 sets of 2 cells each, in multiple, giving a total voltage of 5 volts instead of 10 volts as in the preceding problem and the discharge current assumed as the same, .3 of an ampere continuously, how long will the battery last? Show sketch of the connections.

Ans. 76. If the battery of problem 75 had been connected 2 in multiple, 5 in series combination, the voltage would have been only 5 volts. If the external resistance is reduced to half, so as to allow .3 of an ampere current to flow continuously, as in problem 75, this current will then be furnished by 2 sets of cells in parallel and the current through any one cell will be approximately half of the total current or, .15 amperes.

This current flowing continuously would consume (24 x 15) or 3.6 ampere hours daily from each battery. The total battery capacity of 250 ampere hours would then last (250 divided by 3.6 or) practically 77 days. Comparison of the 2 circuits may be noted from the accompanying diagrams.

Ques. No. 77. Just what is the difference between 4 cells connected in series and the same cells be connected in multiple? Show sketch. If each cell generates a potential of 1 volt, what is the potential delivered to the external circuit in each case?

Ans. 77. The accompanying sketches show the difference between 4 cells connected in series, as in Fig. 27,

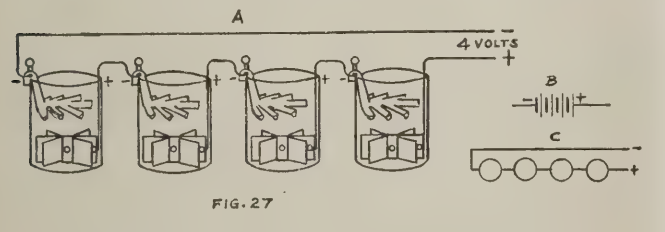


FIG. 27

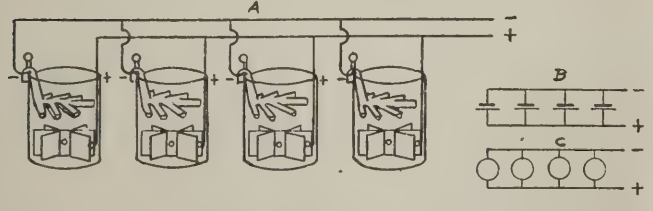


Fig. 27. Series Connection, Above, and Fig. 28, Below, Showing Multiple Connection of Batteries

and the same 4 cells connected in parallel, as shown in Fig. 28. The small sketches B and C indicate the graphical method of showing battery connections for both series and multiple. If each cell generates a potential of one volt with 4 cells in series, the total voltage generated will be 4 volts, but with the same cells connected in parallel, the total voltage would be only 1 volt. The parallel combination, however, could deliver four times the current that the series combination could, provided the resistance of the external circuit was adjusted to proper value.

Problems for Next Month

Fractions, First Lesson.

1. Reduce to a common denomination the fractions 2/15, 5/20 and 1/4.
2. Reduce to the lowest terms the fractions 5/16, 10/20 and 7/21.
3. Change to mixed numbers the fractions $\frac{18}{4}$, $\frac{26}{5}$ and 4/3.
4. Change to improper fractions the mixed numbers 3 1/4, 5 1/3 and 6 1/5.
5. Add the fractions 1/2, 1/4 and 1/8.
6. Add the fractions 1/7 and 1/4.
7. Add the fractions 1/5, 1/6 and 3/9.
8. Subtract the following: 6/10 minus 2/5; 4/5 minus 1/3 and 2 1/4 minus 7/8.
9. Multiply 2/5 x 1/4 x 1/3.
10. Divide (a) 1/4 by 1/2, (b) divide 4 by 1/3, (c), 3 1/2 by 2/5.

Second Lesson—Decimals.

9. Write out in words the following: (a) 12.26, (b) 4.015, (c) 17.2423.
10. Add the following: 13.27, 1.329 and 148.435.
11. Subtract, (a) 7.48 from 135.27, (b) 4.328 from 7.02.
12. Change the following to a common fraction and add .25, .375, .50 and .125.
13. Change to decimals: 1/5, ¼, ⅓, ¾, 8/10 and 2/25.
14. Multiply: (a) 7.4325 × 2.27, (b) 75.387 × 2.52.
15. Divide: (a) 3.25 × .25, (b) .38 × 2.27, (c) 1.045 × 3.75.

Third Lesson—Ratio and Proportion.

16. What is the difference between arithmatic and geometric ratio?
17. What is meant by inverse ratio and direct ratio?
18. If the resistance of two similar conductors varies inversely as the square of their diameters, how does the resistance of a rod 300 mills in diameter compare with 150 mills in diameter?
19. If 25 men can do a certain piece of work in 45 days, how long will it take to do the work if 10 extra men are added, assuming that the new men work with the same speed as the original 25.

Fourth Lesson.

20.—Raise the following numbers to the powers given: (*a*) 2^2, (*b*) 5^2, (*c*) 12^2, (*d*) 4^3, (*e*) 8^3, (*f*) 5^5, (*g*) $(3\frac{1}{2})^2$, (*h*) $(5\frac{1}{2})^2$, (*i*) $(8\frac{1}{3})^2$.

21.—Find the square root of the following: (*a*) 169, (*b*) 400, (*c*) 132, (*d*) 3, (*e*) 1.025, (*f*) 16.01.

22.—Find the cube root of (*a*) 614.125, (*b*) 1000.00, (*c*) 373.248.

23.—How many litres in a tank in the shape of a cube 3 ft. on a side?

24.—A walk is made of boards 6 in. wide, 1¼ in. thick, and the boards are laid crosswise with ½-in. space between them. The walk is 3 ft. wide, but the boards are 10 ft. long, causing a waste of 1 ft. on each board. If the walk is 500 ft. long and the boards cost $25.00 per M. ft., how many board ft. should be ordered and what will it cost?

Fifth Lesson.

25.—Assuming that chestnut poles weigh 55 lbs. per cubic ft., what will be the weight of a pole 40 ft. long having top diameter of 8 in., butt diameter 13½ in.?

26.—What should be the length of each of the rods to form a hoop for a circular water-tank at a point where the outside diameter is 12.4 ft., if the rods should lap 4 in. to make a good joint and there are 4 joints in the hoop?

27.—If this is the lower hoop and comes over the joint for the bottom, and the thickness of the boards in the side is 2 in., what is the inside area of the bottom?

28.—What is the area of a square platform the side of which will just come flush with the outside of this tank?

29.—If this tank had been square and held the same number of gallons, (*a*) what would be the inside circumference, assuming that the height is the same as the circular tank? (*b*) Outside circumference or perimeter?

A. B. C. Car Lighting Course

Edited by Edward Wray

Lesson No. 26

The Resistor Type Ampere Hour Meter

There are several kinds of ampere hour meters designed to meet the various requirements of storage battery service, so before beginning a detailed description of the meter construction and operation we will consider for a moment the general proposition of the ampere hour meter as employed in car lighting service. Ampere hour meters have been used for many years in storage battery service but it was not until the advent of the mercury type ampere hour meter in 1908 that they were applied in practical service to any extent.

Straight Storage System.

The first mercury meter built was a simple shunt type without any auxiliary contacts or other automatic features whatever; it simply recorded true ampere hours, the dial hand revolving slowly in one direction on discharge, and in the reverse direction on charge. In order to make the meter act automatically so as to cut off at the end of charge, a re-set device and zero contact was added so that when the battery was placed on charge the meter could be set ahead 10 or 20%, (as desired) of the number of ampere hours discharge and when the hand got back to zero a charge of 10% or 20% more than the previous discharge would have been given the battery; the zero contact would then operate a circuit breaker and stop further charge. Several roads still use this type of meter in their straight storage service.

In order to make the meter still more automatic, a differential shunt device was added to make the meter automatically run 10% to 20%, (as desired) slower on charge than on discharge and this would take care of battery losses in the same manner as setting the meter ahead 10 to 20%, as mentioned above.

Head End System.

In this service the duplex train or the resistor type meter can probably be used to best advantage since the battery must never be disconnected from the lighting circuit. The duplex train meter has no contact or other operating mechanism, but simply records true ampere hours charge and true ampere hours discharge. When the battery discharges, the current causes the meter to revolve in a direction which operates the discharge gear train and dials. When the battery is charged the current flows in the reverse direction and the meter will rotate in the reverse direction, engaging the charge gear train and dials, meanwhile the discharge dial will not be operated until the current flows in the discharge direction.

By taking the readings of both the charge and discharge at the end of every day's run, the operator will have a record of the operation of the battery and can see at a glance whether he is undercharging or overcharging the battery.

Considerable care must be exercised in making use of these ampere hour meter readings, and the simple fact that a meter may show a total charge in excess of the discharge should not be taken as a definite indication that the battery at that time is even fully charged. The past history or daily readings must be considered rather than the totals. For instance, a case came to the writer's attention recently where a duplex train meter was placed on an axle equipment and during the first 5 days the battery received a very heavy overcharge of approximately 300 ampere hours per day, a total of 1,500 ampere hours overcharge. On the following days, however, due probably to belt slipping, the charge was greatly reduced so that the batteries were undercharged by approximately 30 ampere hours per day. In 10 days, or a little over two weeks after the battery was put into service, it was in a fully discharged condition, although the duplex train meter indicated that an overcharge of 1,200 ampere hours had been given the battery. The point is that this overcharge came all at one time instead of being distributed as it should have been, and without a complete record of the daily readings of the equipment, the electrical engineer or chief electrician might be entirely mislead as to the actual state of affairs and probably blame the ampere hour meter for being inaccurate.

The resistor type meter can be used for automatically stopping the charge when the battery on a head end system gets up to full capacity in a manner very similar to that employed for axle equipment, which will be described later.

Axle Generator System.

The duplex train meter can be advantageously employed for simply indicating the total charge and total discharge the battery receives, but neither the simple shunt, differential shunt, nor duplex train meters can be employed for automatically controlling the charge given a storage battery on an axle generator system. A special meter for this purpose, however, has been developed, known as the "variable resistor" type ampere hour meter, which is described in another part of this lesson.

In this service the storage battery may be charged in a few hours, then discharged a short time at a station, then another period of charge enroute and another discharge at a station, etc., repeating this cycle many times before the battery comes to a point of full charge. It is well known that any storage battery must be given a greater number of ampere hours charge than it is capable of delivering on discharge, depending upon the ampere hour efficiency of the battery. This efficiency, however, is not a definite factor as might be considered on first thought, but depends on many variable factors, such as current rate, temperature, and strength of electrolyte, condition of plates and the nature of the charge and discharge, that is, whether it is charged and discharged alternating every few minutes, using only a small part of the total capacity of the battery.

In electric railway floating battery work, where the battery may be charged one second and discharged the next, the ampere hour efficiency may be very high, in

some cases even as high as 98%. In axle generator operation where the battery is worked daily over from 25% to 50% of its capacity and fully charged each day, the ampere hour efficiency will run somewhere between 80%, and 85%. On the other hand, if the battery is charged and allowed to stand a week or more before it is discharged it may lose its charge very appreciably, particularly if there be any slight grounds or short circuits between plates; the ampere hour efficiency would then be very low.

In applying the ampere hour meter principle for controlling the operation of axle lighting systems, we must decide on some battery ampere hour efficiency which will approximate the condition found in this service. It should be remembered, however, that it is better to assume an efficiency too low than too high, as this will be on the safe side in providing a charge of a little more than necessary. The setting of 80% efficiency, allowing an overcharge of 25% will probably be found ample for car lighting service, in fact an over charge of 20%, representing a battery efficiency of 83%, should be sufficient for most cases.

If it is found in the application of ampere hour meters on certain classes of cars, such as business cars, that the loss on standing, due to leakage, causes a serious error in the operation of the equipment, this can be compensated for by assuming this leakage at a certain rate, and providing a thermo-couple in the meter, which will cause the meter to run in a discharge direction very slowly all the time the battery is standing on open circuit.

From the above discussion it is evident that the variable conditions of temperature, current rate, condition of plates, etc., which were shown in our last lesson, to very seriously influence the operation of voltage regulating devices, also affect the operation of the ampere hour meter. There is a great difference, however, between the voltage and ampere hour meter principles in the degree of influence of these variations affecting the charge given the battery. A voltage setting of even 2% too high may prevent the stop charge or other voltage device from working, for the charging voltage of the battery may never reach that value and the storage battery will then continue to overcharge at the normal current rate all the time the generator is operating. On the other hand, an error of even 100% in assuming battery efficiency, that is, if an efficiency of 80% (allowing 25% overcharge) had been assumed, when in service it is found that the battery really operates on a 90% efficiency basis (only 11% overcharge required), it would mean that if a 300 ampere hour battery is discharged 100 ampere hours each day, the charge given the battery will be 125 ampere hours, whereas it should have only received 111 ampere hours, an overcharge of only 14 ampere hours or 5% of the total battery capacity, daily.

This, which represents probably a maximum error, would in no way injure the battery; on the other hand, even a slight error in voltage setting of a stop charge relay may cause the relay to operate too soon and never bring the battery up to full charge, or the relay may never operate and thus allow the generator to overcharge the battery, in some cases which have come to the personal notice of the writer, amounting to 7 hours daily overcharging at 40 amperes.

It is therefore seen that although both the voltage system of control and the ampere hour meter control are affected by the above mentioned variations in temperature, current rate, etc., there is a great difference in the ultimate effect of these variations on battery operation.

With the Edison battery where there is no change in gravity of the electrolyte on charge or discharge, the ampere hour meter readings are the only reliable indication of the battery charge.

The resistor type ampere hour meter is being extensively applied by two companies operating a large number of axle lighting equipments and it will be interesting indeed to note the results obtained. Although this involves the application of an entirely new principle in car lighting equipment, the success with which ampere hour meters have been applied to other classes of storage battery service, such as vehicle and central station types, in which the ampere hour meter indication is considered fully as accurate and, of course, far more convenient than the specific gravity method of control, would lead us to expect that this principle of battery operation could be applied, with possibly a few modifications, to meet the special requirements of axle car lighting service.

The Resistor Type Meter.

With the extensive application of the resistor type ampere hour meter for controlling the operation of axle lighting systems a detailed description of this apparatus will be of interest, but first we will consider the fundamental principles underlying the operation of the meter.

An ampere hour means 1 ampere of current flowing for 1 hour, ½ ampere for 2 hours, 4 amperes for 15 minutes, etc. In other words, it is simply a measure of current and time and has no reference to the voltage.

By employing a heavy permanent magnet to create the magnetic field of the meter instead of a voltage coil, as is done in watt hour meters, the ampere hour meter records ampre hours instead of watt hours. The ampere hour has been selected as standard for battery work in preference to the watt hour, for the reason that the ampere hour efficiency of a storage battery is far more reliable than the watt hour efficiency since the latter would include all the variations of voltage with varying temperature, current rate, etc., as well as those variations of the ampere hour efficiency as mentioned above.

We learned in the second lesson of this course that when a wire carrying a current is placed in a magnetic field it tends to move out of that field in a direction perpendicular to the lines of force and perpendicular to the axis of the wire. This is due to the reaction between the magnetic lines of the magnetic field and the magnetic lines circiling around the wire carrying the current; it is the same principle which makes a motor revolve.

The force with which this wire will move out of the magnetic field will depend upon the strength of the field and upon the amount of current flowing through the wire. If the field is maintained constant, and the current through the wire doubled, it will move with twice the force, etc.

The ampere hour meter consists of simply a circular disc of copper floated in mercury. The float chamber is so adjusted that the entire weight of the moving element, consisting of the copper disc, shaft and damping disc, are all carried by the buoying effect of the mercury. This has been carefully adjusted in the manufacture of the meters so that there is a very slight upward pressure of about 1-10 of an ounce. Because of this principle, even the most severe vibrations do not affect the rotating mechanism of the meter any more than it would damage a piece of ice floating in a tank of water, to pound upon the side of the tank.

Contact is made into the mercury chamber at points diametrically opposite and current passes directly across the disc as indicated by the small arrows, Fig. 139, contact being made through the mercury. The pole faces of the permanent magnet come directly below the mercury chamber, as shown in the Fig. 139, and the magnetic lines travel from the north pole, through the copper disc into a circular iron ring, shown in section in the diagram, through this ring to the opposite side of the copper disc, thence again through the copper disc to the south pole. It is thus seen that the magnetic lines are going in an upward direction at the left hand side of the disc and downward at the right hand side.

The current passing across the copper disc encounters two magnetic fields, the magnetism of one

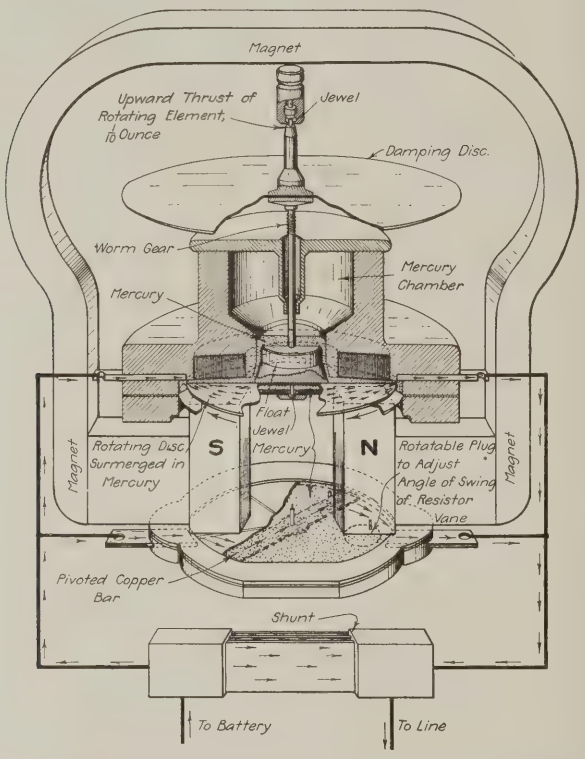


Fig. 139. Showing the Direction of Current Flow and Meter Rotation with Battery on Discharge. Small Arrows Indicate Direction of Current Flow and the Larger Arrows Indicate Direction of Rotation of the Meter Disc

being directly opposite in direction to that of the other. With the current going in a discharge direction as shown in Fig. 139, the magnetic reaction would tend to move the left half of the disc, which corresponds to the wire carrying the current above mentioned, in a direction as shown and this same current, when passing through the other magnetic field on the opposite side of the disc, would tend to move it in the opposite direction. The effect of these two forces acting in opposite directions at opposite sides of the disc, simply cause it to rotate and, as explained above, the force with which this disc rotates will increase directly with the increase in current through the disc.

The damping disc, which consists of a thin sheet of aluminum revolving between magnet poles, provides that the meter will run at a speed directly proportional to the amount of current flowing through the disc, i. e., twice the current will make the meter run twice as fast, etc. When the current through the disc reverses the disc will be rotated in the reverse direction.

Gear Train and Dial.

A worm gear is mounted on the shaft of the meter disc and as this revolves it drives a gear train. The last gear of the train operates the indicating dial of the meter. The 10 ampere meter is adjusted so that a current of one ampere will cause the disc to rotate at a speed of 100 revolutions per hour. In other words, 100 revolutions of the disc represents one ampere hour. If the dial of the meter is laid out so that ½ revolution of the pointer indicates 300 ampere hours there must be 300 times 100 revolutions of the dial to rotate the dial hand ½ revolution, or 30,000 revolutions to rotate the dial hand ½ revolution.

The Variable Resistor Element.

As explained in the first part of this lesson, the storage battery must receive a charge of from 10% to 25% greater than the previous discharge depending on the frequency and amount of discharge, in order to make up for battery losses. In the variable resistor

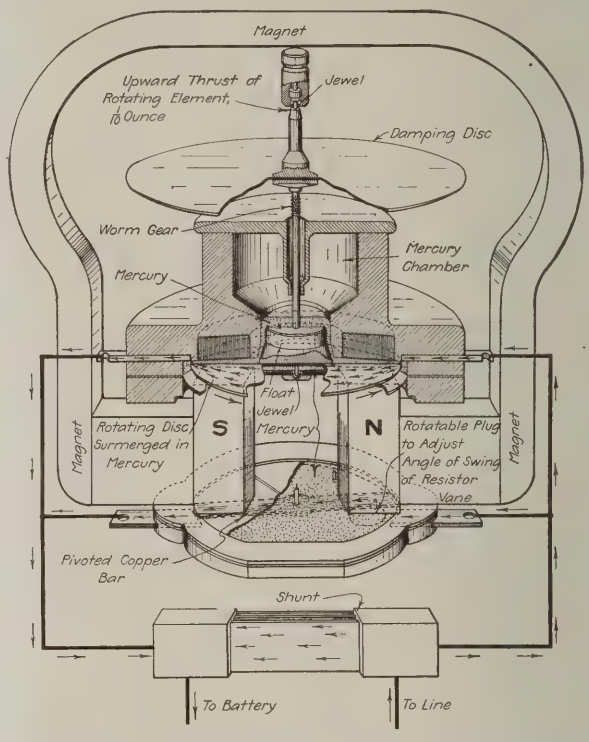


Fig. 140. Direction of Current Flow Through the Meter on Charge. Note that the Resistor Bar has Moved Through a Slight Angle and is Now Almost in Line with the Contacts. This Increases the Current Through the Resistor and Decreases Current Through the Meter Disc, Causing it to Run Slower on Charge

type meter this feature is automatically provided for by making the speed on charge only 80%, (or any other desired value) of what it would be with an equal amount of current flowing in the discharge direction. In other words, on discharge the meter registers true ampere hours, and on charge it registers only 80% of true ampere hours.

This is brought about by means of the resistor element, which consists simply of a small bar of copper pivoted at the center and immersed in mercury. This bar is free to revolve through a slight angle from a position directly between the two contact points at opposite sides of the mercury chamber to an angle of 40 degrees therefrom. The movement of this bar is limited by two stops, one of which is adjustable as shown in Figs. 139 and 140.

This resistor element is clamped below the main mercury chamber of the meter and there is sufficient magnetic leakage from the poles of the permanent magnet to provide a weak field for the resistor element. Current flowing through the pivoted copper bar of the resistor element will then have the same effect as

current through the meter disc, it will cause it to rotate. This rotation, however, is limited to a slight angle by an adjustable stop in the resistor chamber, as shown by Fig. 140. When the current through the resistor reverses from a charge to a discharge direction, or vice versa, the resistor will rotate in the reverse direction until it strikes the other stop.

An adjustable dial on the bottom of the resistor element connects through the resistor chamber to a circular plate carrying the two stop pins, which limit

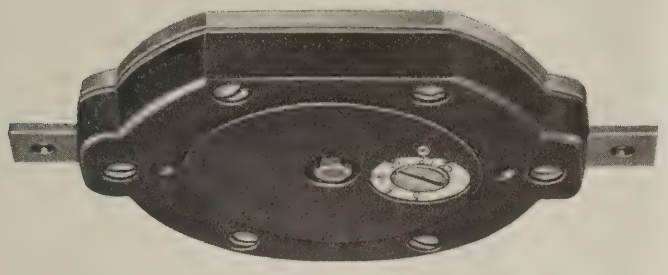


Fig. 141. Bottom of the Resistor Element Showing the Adjustable Feature Whereby Meter Can Be Set to Provide Any Desired Overcharge from Zero to 25 Per Cent

the movement of the resistor bar. A graduated scale is provided so that the position of these pins may be adjusted to cause the meter to operate at any percentage of battery overcharge desired between the limits of zero and 25%.

It will be noted from diagrams, Figs. 139 and 140, that the resistor, the meter disc and the shunt provide three parallel paths for the current passing through the meter. When the current is flowing in a discharge direction it causes the resistor bar to be rotated to an angle of about 40 degrees from the line of direct contact through the resistor. This will make it necessary for the current through the resistor to pass through a short section of mercury at each end of the resistor bar.

The resistance of mercury is approximately 60 times greater than that of copper, so when the resistor bar rotates and causes the current to flow through a section of mercury at each end, it introduces a slight resistance in the path of the current through the resistor. In other words, the propertion of current through the resistor will be much less on account of the resistance of the mercury, than when the resistor bar lies directly between the two contacts.

The meter is designed so as to register true ampere hours on discharge, at which time the resistor has its maximum resistance. Current flowing through the resistor at this time will then be a minimum and that through the meter disc will be at a maximum. When the current reverses and flows in a charge direction, the direction of rotor bar will be moved to a position making almost direct contact between the terminals of the resistor chamber. This will greatly reduce the resistance of the resistor and accordingly increase the current flowing through it. This in turn, will reduce the current flowing through both the main shunt and the meter disc and accordingly make the meter record more slowly on charge than on discharge for an equal current through the battery.

Meter Contacts.

By referring to Fig. 142, showing the view of the meter with the case removed, it will be noted that there are two contact points, one at zero and the other at approximately 10 ampere hours. As the meter discharges the dial hand moves in a clockwise direction, but when the generator begins to operate and charges the battery the meter hand will move in the reverse direction, recording battery charge at a rate of approximately 85% of the true ampere hours.

When the dial hand gets back to zero the previous discharge, plus 20%, will have been put back into the battery and accordingly the battery wil be up to full capacity. At this point a contact is made which closes the circuit through a double acting relay, which in turn performs a certain function, depending upon the particular type of axle equipment, to stop further charge. In a future lesson we will take up the matter of application of the ampere hour meter principle to all the various types of axle lighting, as well as head end systems.

When the zero contact "A" is closed the voltage of the generator is reduced to such a value that it will simply float the batteries, and although no further charge will be given the battery, it will not be called

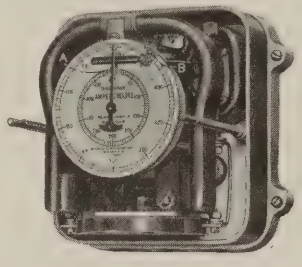


Fig. 142. The Variable Resistor Type Ampere Hour Meter with Case Removed. Contact at "A" Stops Further Charging and Contact at "B," After a Slight Discharge, Restores Normal Operation of the Equipment

upon to carry the lamp load until the next stop. After a discharge of 30 ampere hours has been taken out of the battery at stops the dial hand will make a second contact at the point "B" Fig. 142 and energize the other coils of the double acting relay, restoring the axle generator equipment to normal operation. Normal conditions will then exist, charging the battery, etc., until the dial hand again gets back to the zero contact point when the cycle will be repeated.

In this way, after the battery once becomes charged on the road the ampere hour meter control keeps it to within 10 ampere hours of full charge. It should be noted, however, that the meter does not in any way interfere with the operation of the equipment until the battery becomes fully charged.

Some trouble has been experienced with ampere hour meters becoming inaccurate after being in service a few months. This, however, has been found to be caused by mercury chamber warping slightly, due to overheating in regulator lockers. A recent improvement in the molding the mercury chamber will obviate this difficulty as this material withstands heat up to 350 degrees Fahr.

FACTORY LIGHTING.

This is the title of a new book by Clarence E. Clewell, formerly lighting expert of the Westinghouse Cos. It tells in a simple way how to obtain good lighting for factories, drafting-rooms, power houses and offices. It is based on a broad experience in lighting installations under a wide variety of conditions and treats the various problems from the standpoint of individual installations. Actual results are given precedence over generalized statements. It covers a wide range of problems in lighting for various classes of work, with the solutions that have been obtained by the author in practice. Price $2.00 net, postpaid. McGraw-Hill Book Co., New York.

Prize Question Box

A good Question Box Department can be made a mighty valuable part of our A. B. C. Car Lighting Course, so we are going to make a special inducement to the boys to boom this thing and make it a success.

As a first prize for the best question asked, we will give $1.00 in cash; second prize, nine months' subscription to the RAILWAY ELECTRICAL ENGINEER and third prize, six months' subscription.

Better send in your questions now, while you think of it.

Questions Before the House

Care of Ball Bearings.

Since the grease gun has not been found satisfactory for car lighting generators, on account of the fact that it is able to force grease out of the housing into the generator case itself, it has become the practice on some roads to grease the machines only at intervals of six or eight months, at which time the heads are opened, bearings taken out and cleaned and regreased. There seems to be more or less diversity of opinion as to the best method to be followed, whether to shop the generator and give them a complete overhauling, or to simply remove the heads and regrease the bearings without removing same from the car.

It would be interesting to hear the comments of different car lighting men on this subject.—L. S. Billau.

Axle Generator Alignment.

I should like to obtain some information through the Question Box covering quick and easy methods of checking the alignment of axle generators with reference to car axles and which are suitable for use in checking up cars in service and undergoing periodic inspection.

Methods I have seen involve measurements beween axle equipment and the rail or the car axle itself, both of which are apt to result in error if the axis of the axle is not at right angles to the rail or in case the axle is not at right angles to the pedestals due to lost motion in journal boxes, etc.—L. S. Billau, Elec. Dept., B. & O. R. R.

System of Handling Repairs to Axle Equipment.

What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Brake Beam Position.

Should the truck and generator suspension be designed so as to make the lower run of the car lighting belt pass under the brake beam or over it?—Edward Wray.

Ball Bearings.

Why was a ball bearing large enough for a 16-ton automobile truck adopted as a standard ball bearing for axle dynamos?—Frank Rupple.

Field Fuse Trouble.

No. 3. On Bliss equipments I find that the shunt fuse will almost invariably blow if the automatic switch does not close or if there is an open in the battery circuit. But on the Moskowitz type of equipment I quite often find that the automatic switch does not close and yet the shunt fuse does not blow as it would in a Bliss equipment. Will you try to furnish an explanation?—S. W. Everett, Santa Fe.

Current in Moskowitz System.

No. 4. Why does the current run up on a Moskowitz equipment as the speed of the train increases? That is, if the dynamo is set for 30 amperes when the train is running at 30 miles an hour and when the speed of the train increases to 50 miles per hour, you will find that the output of the machine has raised almost double, to perhaps 45 or 50 amperes.—A. E. Voigt.—Santa Fe.

First Prize

Loss of Battery Capacity on Open Circuit.

Ques. What should be done when the battery gradually discharges and looses capacity on standing on open circuit a few days in the yard? J. G. Koppel.

Ans. This indicates that there is either a ground in your circuit or a short circuit in one or more of the cells, or possibly both. In order to determine whether it is a ground or short circuited plates, take voltage readings of all cells on discharge. If some of the cells, near the end of discharge, show abnormally low voltage, and the others nearly or above 1.8 volts per cell, it would indicate that the low cells are causing the trouble. If, however, all of the cells of the battery are low (below 1.8 volts) and all show about the same voltage, it would indicate that the trouble is due to a ground in the car wiring or the external battery circuit. In the latter case, look for grounds either in wiring, fixtures, or wet battery tanks.

If the trouble is confined to two or three cells only, remove those cells and take out the elements. You will probably find that there is a lead tree formation connecting the positive to negative plates (a tiny lead fibrous growth sometimes is found extending through the pores of the separators, or the sediment in the bottom of the tank may be deep enough to touch the plates. Remove either sediment or lead tree formation and charge the cells; they are then ready for service.

Second Prize

Grounded Generator.

Ques. If a car lighting armature becomes grounded it probably will not give full voltage, since the trucks offer a good path for the current to ground. Would you advise in this case that the feet of the generator be insulated? I believe that if this was done the generator would operate just as satisfactorily with a ground as without.—M. E. Schreiber.

Ans. In speaking of a ground it does not mean that the current must pass through or to the ground. As a matter of fact, on a railway car it is very probable that the flow of current will be simply through the car frame, very little, if any, passing to ground.

You may have a ground on either side of the circuit without any serious damage whatever, although it is bad practice to allow this ground to remain; but when the second ground occurs on the opposite side of the circuit, this allows current to flow from the positive ground through the car frame to the negative ground and thence to battery or generator negative, as the case may be, completing the circuit.

By insulating the feet of the generator as you suggest, a ground on one side of the line within the generator would not have any influence on other grounds

in the system even though on the opposite side of the line, for current could not flow from the car frame to the generator frame. But if a second ground on the opposite side of the line occurred within the generator itself, it would not matter how well the feet of the generator were insulated, you would have trouble from these grounds. Although it is probably possible to insulate the feet of a car lighting generator, it is not practicable because of the heavy weight and severe vibration and wear to which the generator and suspension are subjected.

Third Prize

Battery Troubles.

Ques. I had an experience with a battery the other day which I did not fully understand and hope you will explain it through the "Question Box."

Prior to flushing the battery I tested the gravity, which I found to be 1,120, and then flushed the set but owing to lack of time, did not charge the battery that trip. My observation through the vent hole led me to believe that the plates were badly sulphated. The car is on a short run of 123 miles and burns lights receiving in the terminals about 8 hours per day.

On the next trip, or second day after flushing, I tested the gravity and found water; I then placed the battery on charge at 70 amperes for 2 hours, then reduced the charge to 50 amperes for 8 hours more. By taking hourly gravity readings I found that the gravity rose slowly for six hours when it reached a maximum of 1,120. After a continuous charge of 4 hours more and no further rise in gravity, I stopped charge.

On the next trip, two days later, I opened up one cell and found the plates sulphated but it would rub off, so concluded I was safe in charging further. The plates were not buckled and very little mud was in the bottom of the tank, although the battery had been in service without cleaning since March, 1912.

I then added ½ pint of 1835 acid to each cell and charged for 5 hours at 50 amperes. As the cell had not gased any at this time I did not take gravity readings. Two days later the gravity reading was 1,195 so I again placed the battery on charge and at the end of 5 hours the gravity reached 1,220.

What I don't understand is why the charge did not seem to bring the sulphate out of the plates until I added the acid. Was this because the electrolyte was too weak, or were there other causes? I would say the condition of the battery was partly due to acid soaked trays causing grounds. W. B. Hoschke, Toledo, Ohio.

Ans. The mere fact that the acid was weak is by no means the cause of the trouble. Weak acid increases the internal resistance of the battery but decreases the tendency to sulphate. From your statement, that the battery has an 8-hour daily discharge, with only about 4 hours run to bring the battery capacity up, I would say that this extremely severe service undoubtedly resulted in the battery being repeatedly over discharged so that the plates became badly sulphated. When the plates of a battery get into this condition it often times takes several charges and discharges before the battery comes back to full capacity. In the meantime, much of the active material in the plates is in the form of sulphate, which retains the acid in the plates and keeps the gravity low.

Although the fact that you added ½ pint of 1835 acid to each cell, would in itself raise the gravity of the electrolyte about 40 points. This alone would not be instrumental in breaking down the sulphate within the plates. As a matter of fact, increasing the strength of the acid in this way usually tends to increase the sulphation instead of decreasing it. I would suggest that you watch this battery very carefully, for it is probable that even when you brought the gravity up to 1,220 on the last charge, that there was more sulphate still in the plates, which on further charge would be driven out into the electrolyte and raise the gravity still higher. A gravity above normal will make the battery sulphate more easily.

I would call your attention also to the fact that the battery gravity of the electrolyte varies with the temperature. The accompanying table shows how acid, which has been carefully adjusted to 1,220 at normal temperature, will vary throughout the conditions of summer and winter operation.

Variation of Specific Gravity of Electrolyte with Temperature.

Degree Fahr.		Specific Gravity.	
106		1208	
97		1211	
88		1214	
79		1217	
70	Normal	1220	Normal
61		1223	
52		1226	
43		1229	
34		1232	
25		1235	
16		1238	
7		1241	

This means that if the temperature of the electrolyte is 7 degrees below zero, the gravity, if the cell is fully charged and the electrolyte is normal, should be 1,241: on the other hand, if it is in the summer time and the temperature of the electrolyte gets up as high as 106°, the normal gravity is 1,208 and the battery should be considered fully charged if the electrolyte shows this gravity, provided battery is properly flushed.

This indicates the importance of considering temperature in taking gravity readings and making the proper correction for same. A rough and ready rule for remembering this correction is that the gravity decreases one point with every 3 degrees rise in temperature; a temperature of 30 degrees above normal (100 deg. Fahrenheit) would then show a gravity of 10 points above normal.

Testing Axle Equipment.

Ques. If an equipment is not working but the belt is found to be on and no fuse is blown, what is the first test that should be made to find the trouble?

Ans. The fact that the belt is on and no fuse is blown would indicate that there is trouble either in the automatic switch or in the generator field circuit.

Pull the main fuse and connect the lifting coil of the automatic switch to the battery to see if it closes properly; if so, look for open circuits in the generator field circuit. This may be in the carbon pile field resistance, the wiring, or even in the generator fields. In many cases where the pole changer fails to work, the generator will not pick up when going in one direction, but will work all right when going in the other.

Overheated Batteries.

Ques. Why do some batteries heat up more than others in charging?

Ans. The heat developed in a battery either on charge or discharge is due to the resistance of the cell itself. Theoretically if we had a cell of no resistance there would be no heat generated. Therefore, when we note excessive heating, it invariably means that the resistance of the battery is too high. This may be caused by weak electrolyte or sulphated plates.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Easy Rule for Ohms Law.

The accompanying diagrams illustrate a very easy way of remembering ohms law and for figuring current, watts, or volts in any d. c. circuit. By simply covering up the unknown quantity, whether it be volts, current, resistance or watts, the other two known factors will give you the answer.

For instance, if it is desired to know the voltage drop through a certain resistance where the current is known, by covering the unknown (volts) we find that the answer is current times resistance. If the resistance is unknown and volts and current know, by cov-

Diagram for Using Ohms Law

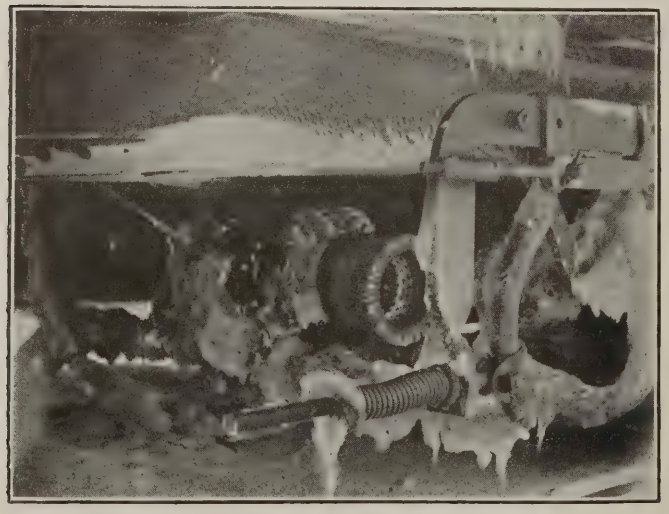
Diagram for Figuring Power Circuits

ering the unknown (R), we find that the answer is volts divided by current, which gives us the resistance of the circuit. If the current is unknown, by covering (C) we find the answer is volts divided by resistance, which gives us the current of the circuit.

Similar with the power diagram, if we simply cover the unknown quantity, the other two give the answer. If the total watts in the circuit are unknown, the current and volts known, we find by covering watts in the diagram that the answer is current times volts. If we know the total watts and total volts, and wish to know the current, by covering (C) in the diagram we find the answer is watts divided by volts. If we know the total watts and current and wish to know the volts, we find by covering volts in the diagram that the answer is watts divided by current.—George B. Colegrove, Ch. Elec. Ill. Cent. R. R.

Ice From the Steam Drip.

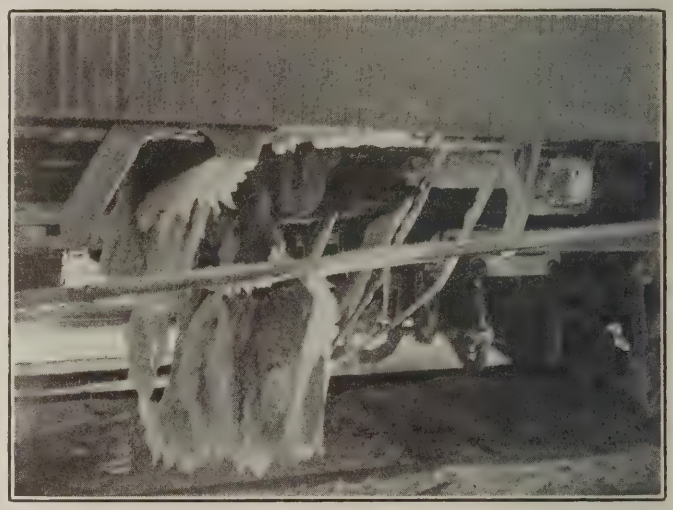
A comparison of the two photographs shown here-



Collection of Ice on Generator, Leads and Suspension from an Unprotected Steam Drip

with, tells a whole story. These two axle generators on the same train, one with steam drip protection, and the other without. In the first case it will be noted that the drip is prevented reaching other parts of the under rigging by the sheet iron shield which projects to within 4 in. of the rail.

The other photo shows a generator without steam drip protectors; there is a collection of ice on the generator, suspension and leads of about 2 in. thick. Part of this was broken off before the photograph was taken. There was also a collection on the face of the armature pulley of almost 1 in. thick. This was thickest near the edges of the pulley, making a concave groove for the belt to run in; just the reverse of the



Steam Drip Shield Protecting the Car Lighting Generator from Collection of Ice

usual crown of the pulley. The belt, however, was still in service.

These photos show the importance of providing proper protection for all steam drips. H. G. Meyers. —Santa Fe.

Commutator Slotting.

I have been following your discussion in previous issues on under cut mica for commutators and have specially noted this feature of the armatures that come to me for repairs.

I find that in the majority of cases where the commutator is slotted to about 3/32 of an inch the copper and carbon dust collect in the slots and short circuit that particular coil, causing the armature to heat. This cannot be remedied unless you turn the commutator down to solid mica again.

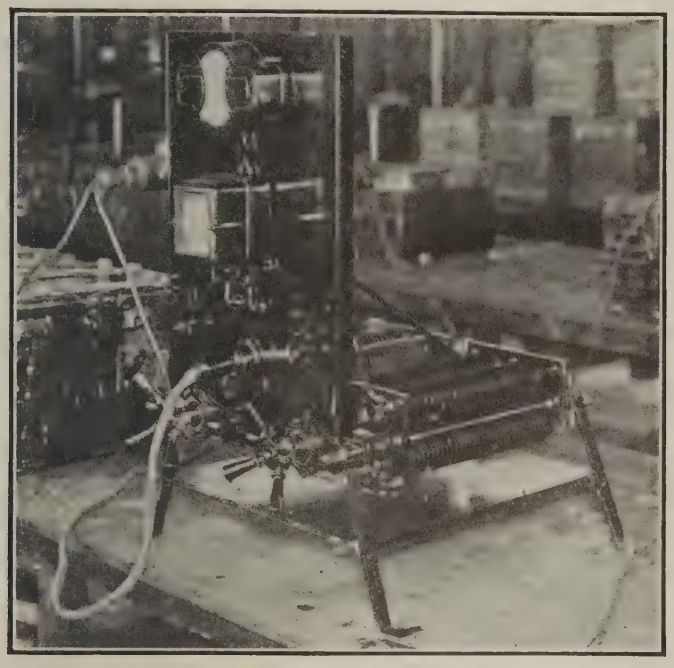
As regards filing with the three cornered file, the objections I find are the length of time it takes to cut the mica down, and also the fact that it is apt to file off the corners of the commutator bars, leaving too large a space between bars, and the hack saw blade stunt is apt to cut too deep.

I find that the best practice is to make a special lathe tool with a diamond shaped point and after placing the armature in the lathe run the tool along the slot, cutting the mica down about 1/32 of an inch.

This makes an even cut along the entire face of the commutator and a man can do the job in half an hour, whereas the other method with a file, takes from 1 to 2 hours, and even then the mica is high near the neck where the file cannot reach.—Robert Downie, Richmond, Calif.

Battery Testing Board.

We have recently built a new testing board for making the charge and discharge capacity tests on batteries immediately after they have been cleaned. This board; as shown in the accompanying illustration,



Portable Battery Discharge Panel Board for Battery House Work

consists of a portable frame with slate panel upon which are mounted volt-ammeter, ampere hour meter, Anderson charging plug and receptacle, Allen-Bradley rheostats, switches, etc.

A record is made of the battery number, date, type, etc., and on both charge and discharge the voltage at the start and finish and the specific gravity at the start and finish are recorded as well as the total ampere hours charge and discharge. If any battery shows up low in capacity individual cell readings are taken and any diseased cells given special treatment.

The entire outfit is made portable so that it can be moved to any point in the battery house in discharging the battery conveniently. The charge or discharge current rate and battery voltage is indicated on the volt-ammeter and total ampere hours charge and total ampere hours discharge are indicated on the ampere hour meter. By means of the carbon resistance it is possible to adjust the current rate, on discharge, to any desired value. Switches make it possible to connect these two resistances either in series or in parallel. They are rated at 2,000 watts each and carry 40 amperes maximum.—Bert Pachaly.

Belt Tension and Suspension Position.

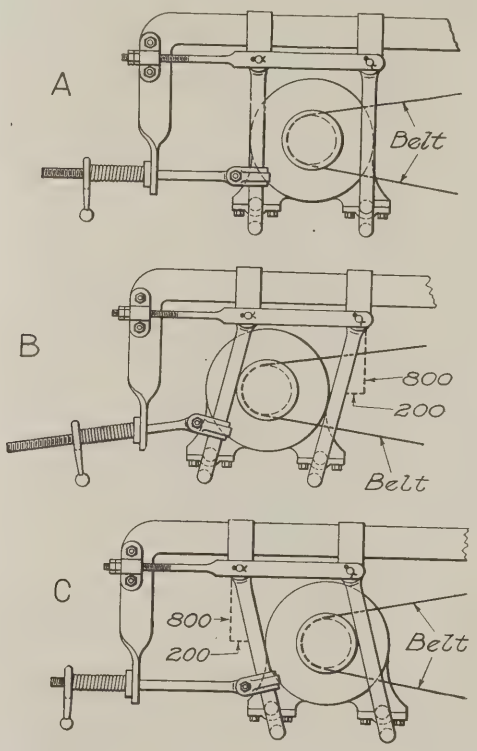
The science of mechanics teaches us that when the center of gravity falls within the base of a body, it will stand, but when it falls outside the base the body ceases to be in equilibrium and will have a tendency to fall.

The principle may be made of practical use to car lighting by the man who maintains axle dynamos and will assist in maintaining proper belt tension.

When the belt is of such length that the suspension links are out of a perpendicular position in one direction or the other, the generator will then tend to fall and bring the links to a vertical position, if they are a suspension loop type. This means that the weight of the generator will have a tendency to pull against the tension spring as in figure "B" or to pull with it as in figure "C."

One unfortunate thing about belts is that they stretch so the tension rod takeup screw must be periodically tightened up until the spring causes proper belt tension. The suspension is then drawn farther and farther back as the belt gradually stretches, until it reaches the end of the thread in a position as about shown in figure "B." A piece of belt is then cut out, the belt shortened and when reapplied the generator will be drawn to a position about as shown in figure "C." As explained above, when the generator suspension is out of perpendicular as in each of these cases, it tends to fall to the center and exerts an added pull either on the belt as in figure "C" or on the tension spring as in figure "B."

The amount of this pull will depend upon how far the



Showing the Stresses on Spring or Belt with Various Positions of Generator Suspension

suspension is drawn out of perpendicular. The small triangle represented by the dotted lines in Figs. "B" and "C" indicates the measure of this force. From these sketches, which might be taken as extreme conditions, it will be seen that the horizontal dotted line is about one-fourth of the vertical dotted line. The vertical line indicates the weight of the generator, and horizontal line when drawn through the center of gravity of the generator indicates the horizontal force on either the belt or spring, as the case may be. Under this extreme condition a generator weighing 800 lbs. would exert an additional pull of 200 lbs. on either the belt or the spring. If the angle which the suspension is out of perpendicular is but one-half that shown in the diagrams the pull on either spring or belt, will be half.

In figuring this horizontal pull of the generator at 200 lbs., we assume that the generator is stationary and the car at rest. We all know that when an object is struck with a hammer the force of impact is far greater

than the weight of the hammer. It depends upon the velocity of that hammer and upon how springy or rigid the object struck is. With the generator mounted directly on a steel truck there is often severe bouncing up and down which makes the generator act very much like a hammer on its suspension. The force of the generator under these conditions may easily be three or four times its own weight; and the horizontal pull of the generator on either the belt or spring will be correspondingly large. This shows the great importance of keeping the generator suspension in as nearly perpendicular position as possible, for if badly out of perpendicular the generator may pound the belt with over a 1,000-lb. blow in addition to the pull of the spring.—W. J. Dawson.

Reflectors for New High Efficiency Mazda Lamps

To meet the rapidly growing demand for lighting units to accommodate new high efficiency 750 and 1,000 watt Mazda lamps, the Holophane Works has just completed the development of a line of reflecting

Fig. 1. New Semi-Direct Unit with Prismatic and Diffusing Glass Combination for New High Efficiency Lamps

and diffusing units for this service. Because of the high intrinsic brilliancy of the new lamps, as well as the high temperature of the filaments and necessary change in lamp construction, it has become necessary

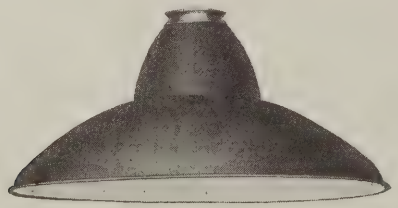


Fig. 3. Shallow Bowl Enameled Steel Reflector for New High Efficiency Lamps

to develop this entirely new line of lighting units to accommodate the new lamp.

These units, as shown in the accompanying illustrations, include enameled steel, prismatic and diffusing types. There are many different designs, but the three shown in the accompanying illustrations are typical of each class.

For the illumination of stations and waiting rooms the two more decorative types will probably be preferred. The semi-indirect unit, as shown in Fig. 1, consists of a Druid glass outer envelope within which is suspended a prismatic glass reflector; this latter directs the light upward toward the ceiling. Air passes downward between the reflector and envelope and upward through the center of the reflector, passing between the lamp and reflector.

The diffusing unit, shown in Fig. 2, consists of an

Fig. 2. Diffusing Unit for New High Efficiency Lamps

outer envelope of heavy density opal with a bowl at the bottom of crystal roughed glass. Air enters around the lower band of the fixtures and escapes through the hood above.

For illumination of platforms, shops, yards, etc., two

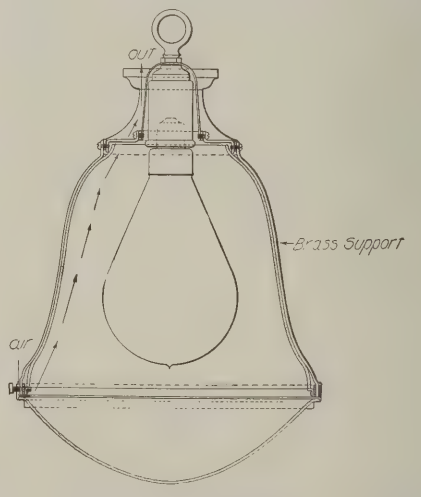


Fig. 4. Section Through Diffusing Type Unit

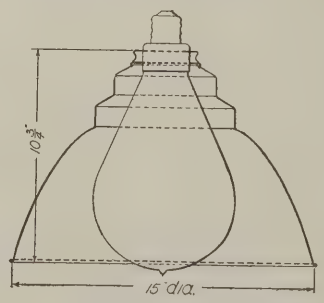


Fig. 5. Section Through Deep Bowl Enameled Steel Unit

types of enameled steel reflectors have been designed, the deep bowl B.E.E.-1,000 and the shallow bowl B.E.D.-1,000. The screening angle of the shallow bowl unit, shown in Fig. 3, is 85 degrees, while that of the deep bowl unit is approximately 70 degrees.

Personal Mention

S. W. Everett, Appointed Elec. Engr. of the Santa Fe

On February 1st, 1914, Mr. S. W. Everett was appointed electrical engineer of the Santa Fe system to succeed Mr. Francis R. Frost, recently deceased.

Mr. Everett was born in 1868 and received an education at Topeka and the University of Kansas at Lawrence, Kans. At the latter place he took a special course in electrical work. His first actual experience in this line, however, was with the Topeka, Edison Company, where he worked for a number of years. His first car lighting work was with the National Car Lighting Company in 1896, and shortly afterward was employed by the Consolidated Railway Electric Lighting & Equip. Co., at Topeka in connection with their maintenance of axle lighting equipment on the Santa Fe. Later this work was taken over by the Santa Fe and Mr. Everett entered the Santa Fe service on May 18th, 1901, at Argentine, Kansas, as axle light inspector.

On July 1st, 1904, he was promoted to the position of assistant electrical engineer, where he ably assisted in bringing the car lighting service of the Santa Fe up to its present high standard of reliability and economy.

In 1905 Mr. Everett invented an exceedingly simple system of regulation for axle generators, consisting of two carbon contacts, each short circuiting a section of resistance permanentely placed in series with the generator field. Regulation is effected through two solenoids which control the pressure of the two sets of carbon contacts. This system has proved so simple and effective that a large number of these devices have been placed in operation on the Santa Fe.

A. I. Totten Back with General Electric Company.

Mr. A. I. Totten, who in 1911 went to Brazil as mechanical engineer of Brazilian Railways, has returned to this country and has re-entered the employ of the General Electric Company, with headquarters at Schenectady.

Mr. Totten is again engaged in railway work with this company, his present associations being with the railway traction department.

B. F. Wood Leaves Pennsylvania.

Mr. B. F. Wood, formerly assistant engineer in charge of electrical equipment of the Pennsylvania Railroad, has recently received the appointment of chief engineer of United Gas & Electric Company, New York City, and has been elected vice-president of the United Gas & Electric Engineering co-operation.

Mr. Wood has been with the Pennsylvania Railroad for about 17 years and has risen from a draftsman in the motive power department to the position of assistant engineer.

Mr. L. L. Newman, in charge of car lighting equipment of the Pennsylvania Railroad at Pittsburgh, also goes with Mr. Wood. Mr. Newman was in charge of the electrical installation during the construction of the Pennsylvania terminal in New York.

It is reported that Mr. J. V. B. Duer is to succeed Mr. Wood as assistant engineer in charge of electrical equipment.

H. S. Gardner

Mr. H. S. Gardner has recently taken charge of the Chicago office of the Willard Storage Battery Company, succeeding Mr. W. E. Balantine, who has held that position for a number of years. Mr. Gardner comes from the Cleveland office of the Willard Storage

H. S. Gardner

Battery Company and has been in storage battery work for the past 8 years.

Mr. J. T. Foster and T. D. Smith will be associated with Mr. Gardner. Mr. Foster is an old electrical man, having been with the Illinois Traction for a number of years and with the Willard company for the past 5 years. Mr. Smith has had several years experience in electrical sales work in Mexico and South America.

A RECORD IN SWITCHBOARD SHIPMENT.

The Westinghouse Electric & Mfg. Company reports the recent shipment to a large railway company in the Middle West of a twenty-six panel switchboard in record-breaking time.

On the 28th of November the contract for the board was signed, calling for delivery in twenty-six days, with a bonus and penalty clause. On December 10th, or twelve days later, the entire switchboard was shipped complete from the works, and it was done without employing any overtime.

The board is designed to control one 800-kw., 250-volt D. C. generator, two 37½-kw., 250-volt D. C. generators, two exciters, two 850-kva. generators.

With the Manufacturers

Small Rotary Converters for Battery Charging

It is very often found in railroad practice that storage batteries in telegraph, signal and car lighting departments must be charged from a. c. circuits. Motor generator sets and mercury arc rectifiers have been heretofore employed with more or less satisfaction, but it would seem that the new special rotary converter designed by the Northwestern Electric Company of Chicago, has many points of merit over either of the other systems of charging. This equipment is simply a modified rotary converter so designed as to make it as near fool-proof as possible.

One of the principle features consists of a magnetic dampening ring inside of the pole pieces, which will prevent high voltages being induced in the field coils on starting. It might seem that this dampening ring, which is simply a series of punchings made up in the form of a hollow cylinder, would magnetically short circuit the fields of the rotary. On starting there is a heavy leakage of magnetic lines through the dampener ring, but when the machine gets up to voltage the direct current side of the rotary energizes the coils "B," which are in

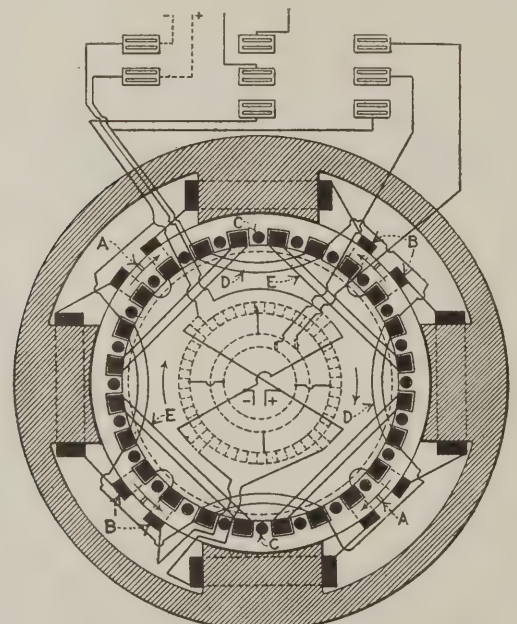


Fig. 1. Diagramatic Section of a Single Phase Machine

series with the field coils of the rotary and these coils oppose the flow of magnetism through the dampening ring so that at normal speed the machine operates without loss from this source.

In Fig. 1 is given a diagrammatic section of a single phase machine showing the starting switch and interior wiring of the machine. It will be noted that the dampening ring is slotted in order that the coils may be embedded in it and so improve the characteristics of the machine. These converters are made at present in any capacity up to 50 kw. for 3-phase circuits and in capacities up to and including 5 kw. on single-phase circuits. It is only necessary to throw the switch in order to start the machine.

Both the single-phase and 3-phase converters are provided with a compensating winding embedded in the slots on inner face of the ring. The difference between the action of these coils and the coils "BB" should be noted, the latter being simply to neutralize the leakage

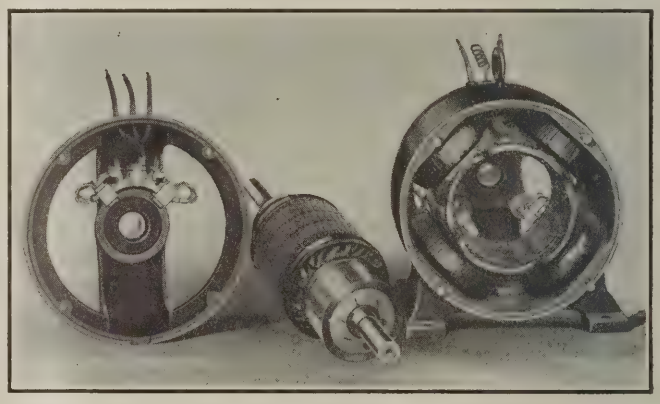


Fig. 2. Single Phase Machine with Armature Removed

magnetism between the poles in normal operation, while the former are to take the place of the original interpole of the direct current generator, that is, they keep the magnetic field of the machine from shifting under heavy load and provide sparkless commutation.

From the wiring diagram, Fig. 1, which is for a single-phase circuit, it will be noted that the machine

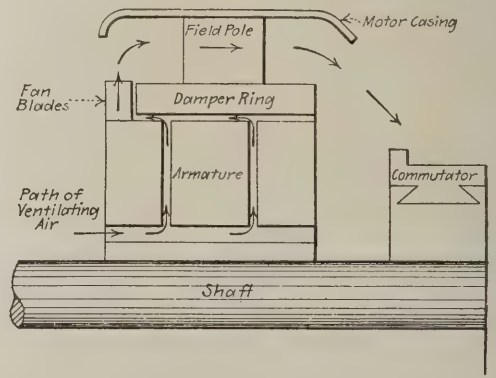


Fig. 3. Diagram Showing Path of Ventilating Air

starts as an ordinary series a. c. motor, but within two or three seconds after closing the switch it rises to synchronous speed and the motor side of the converter then operates as a synchronous motor, delivering direct current to the charging circuit and to the field coils of the rotary. The 3-phase machines start as simple induction motors and quickly come up to normal speed.

In addition to the compensating coils, single-phase machines are equipped with starting windings which are connected in series with the armature circuit when starting and are automatically short circuited when the

starting switch is thrown over. This arrangement assists the compensating coils and the squirrel cage bars, which form the clamping rivets "C" of the magnetic dampening ring in preventing surging of the magnetic flux, and thereby keeping the machine at synchronous speed.

When over-compounding of the direct current charging system is required, to make up for line loss in the yard charging system, etc., this may be provided by simply adding a few series turns of wire over the coils "BB" and the charging current passed through these

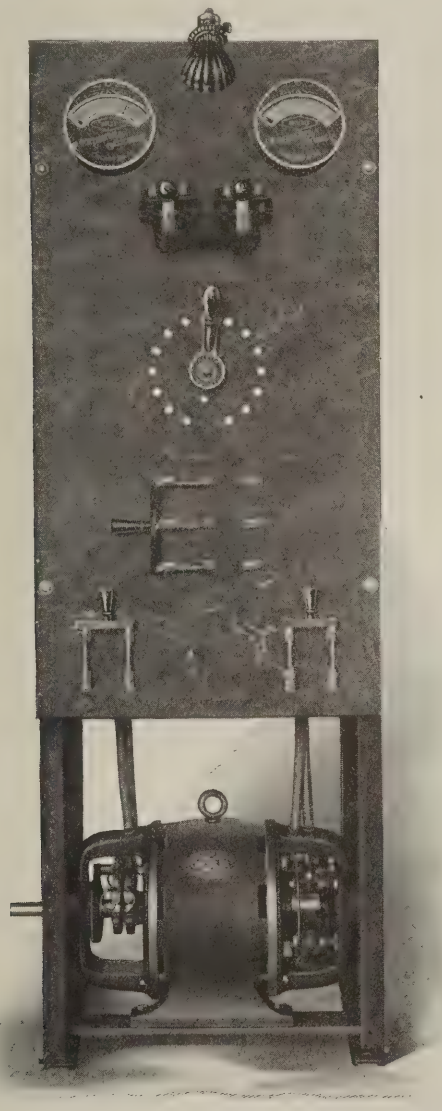


Fig. 4. Complete Panel Board with Rotary Converter

coils, and at the same time placing the proper amount of inductance in the a. c. line. The compensating and starting coils are shaped so as to assist each other in regulating the machine, and when the starting coils are short circuited the pole face area of the stator is increased, thereby making it unnecessary to work the pole pieces at a high magnetic density. Semi-closed skewed slots are employed in the armature to insure quiet running. In addition to the other special features of this machine, it is provided with a new type of forced ventilation which reduces the heating effect on overload and accordingly improves the efficiency. This feature is shown in Fig. 3.

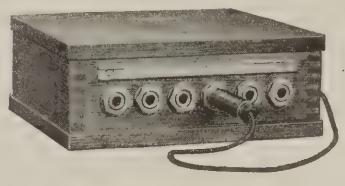
Another advantage of this machine over the mercury arc rectifier is that the direct current system is insulated electrically from the alternating current system so that it is impossible to get a shock from the direct current side of the system through a grounded transformer on the a. c. side.

The voltage on the direct current side may be adjusted to any desired value by simply turning a contact arm, which cuts in or out coils on the primary side of the transformer. In adjusting the d. c. voltage, however, there is no loss similar to a resistance loss, since the adjustment is made by simply increasing or decreasing the a. c. voltage delivered to the rotary.

Manufacturers state that this machine in 10-kw. sizes will operate at a full load efficiency of 84 per cent; ¾ load, 80 per cent; ½ load, 77 per cent; and ¼ load, 62 per cent. This also shows a marked advantage over the mercury arc rectifier, which is less efficient at lower loads. These converters are so designed that they will not run away in case the line opens and battery current comes back in machine.

CORDLESS JACK BOXES FOR WAY-STATION SERVICE.

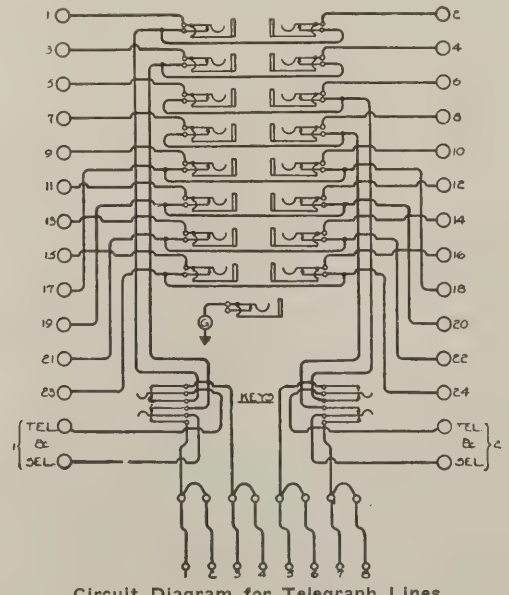
A simple switching device for connecting the operator's set in a railroad way-station to one or more lines passing through the station is found in the cordless jack box recently perfected by the Western Electric Company's railway engineers. The cordless jack box does away with the unsatisfactory knife-switch method of cutting in the operator's telephone or telegraph set on the train dispatching lines. The connection is effected by means of



No. 386 Cordless Jack Box, 6 Lines

a single conductor plug which is inserted in the line jack corresponding to the line over which it is desired to talk or telegraph.

The cordless jack boxes are of two kinds, one for telephone dispatching circuits and the other for telegraph lines, a different style of jack being necessary in the latter case on account of the different nature of the telegraph circuit and apparatus. One distinctive feature of the



Circuit Diagram for Telegraph Lines

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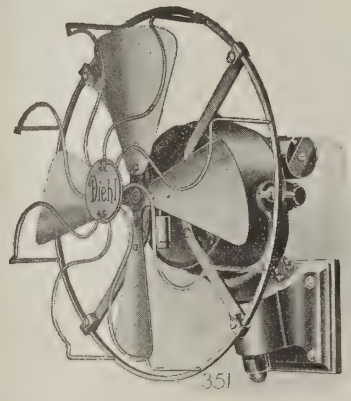

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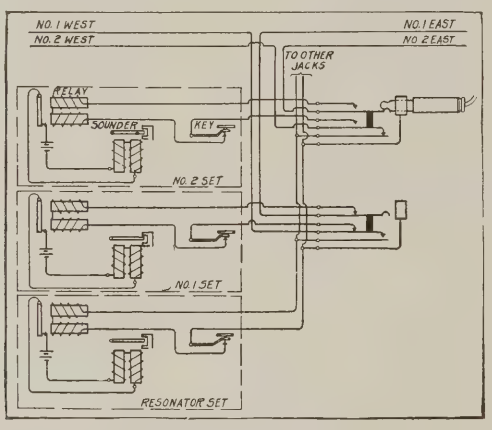
telephone jack boxes is that they may be used to connect two or more lines together and have the operator's set bridged in on all of them, merely by using one or more extra switching plugs.

Solid oak is used in the construction of the jack boxes

No. 389 Cordless Jack Box, 12 Lines

with a cover made of three layers to keep it from warping. This cover is hinged so that it may be opened for inspection. There are no superfluous parts to clutter up the inside of the box. The jacks are made with heavy insulation to prevent trouble from sudden voltage surges or accidental crosses with power or lighting circuits, with all jack springs are widely separated to prevent arcing and burning of insulation. Screw terminals are used for connecting in outside lines. No soldering is necessary. A tie cord is furnished with the switching plug to keep the latter from being mislaid when not in use.

The cordless jack boxes are manufactured in three sizes: the No. 385 type for three lines, the No. 386 type



Circuit Diagram for Telephone Lines

for six lines and the No. 389 type for twelve lines, consisting of two six line units hinged together. Any of the jack boxes can be ordered partially equipped with dummy wood plugs in the unequipped spaces. Jacks can be added at any time by knocking out the wood plugs and screwing in the jacks. Wiring is always furnished for the full equipment.

A number of trial installations of these cordless jack boxes have already been made with gratifying results.

S. K. F. BALL BEARING BULLETIN.

The S. K. F. Ball Bearing Company have recently issued a very attractive bulletin, No. 11, describing the special features of the S. K. F. bearing. The bulletin goes into considerable detail as to the design and manufacture of this bearing and some interesting and instructive information is given. Various applications of the radial and the single and double end thrust bearings are shown and complete instructions for mounting, inspection, lubrication, etc., are given. An interesting feature about the bulletin is the extent to which the various methods of testing bearings and raceways are shown. The bulletin also contains data on power consumption, particularly as applied to line shaft applications.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

(Signed) Edward Wray, Publisher.

Sworn to and subscribed before me this 28th day of March, 1914.
Edw. J. Schumacker,
(Seal) Notary Public.
My commission expires April 8, 1917.

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Battery Flushing

One of the characteristic features of the old constant current car lighting apparatus was that the batteries required very frequent flushing. The rate at which the electrolyte is boiled out, due to decomposition on gasing, is a direct measure of the amount of overcharge which the battery receives.

It is interesting, therefore, to note that with the new types of car lighting equipments, both of the constant potential system and of the combination current voltage system in which the charge is tapered, the necessary periods of battery flushing has been greatly extended. On one of the western roads having had the constant potential system in operation for over 18 months, batteries are flushed only once in 6 months. On another large western road operating axle lighting equipment on an extensive scale, it is found on many taper charge devices the batteries require flushing only once in 5 months.

The frequency of battery flushing necessary is a measure of the overcharge given the battery, and overcharge, to a large extent is an inverse measure of battery life. It is indeed gratifying to learn of the more satisfactory operation in this regard of the recent types of car lighting devices employing constant potential or taper charge principles.

George Westinghouse

In the death of George Westinghouse we have lost not only the greatest American engineer, but probably the greatest engineer the world has ever known. The invention of the air brake alone was a heritage to mankind which would have made any man famous, but this is only one of the results of the many activities of this wonderful brain.

There are few really great men who receive recognition of their greatness during life, but Mr. Westinghouse, possibly because of the unquestionable nature of his achievements, has received many honors and recognitions of his service. His Alma Mater conferred upon him the degree of Doctor of Philosophy; he was decorated with the order of the Legion of Honor, with the order of the Royal Crown of Italy, and with the order of Leopold of Belgium. He was an honorary member of the Engineering Society of Mechanical Engineers, of which body he was also made President in 1910. He was an honorary member of the National Electric Light Association and awarded the Scott medal by Franklin Institute. He received the Edison gold medal for meritorious achievement in alternating current apparatus and also the Grasshof gold medal from the Society of German Engineers in Germany, which acknowledged him the greatest American engineer.

Association News

The dates of the A. R. E. E. 1914 Conventions were decided at the recent meeting of the Executive Committee, as follows:

Semi-annual Convention at Atlantic City, Friday, June, 12th, at the Hotel Dennis.

Annual Convention, October 19th to 23, at Chicago. The place of meeting will probably be the Hotel La Salle, but this is not definitely decided as yet.

Secretary Andreucetti advises that the annual Proceedings of the Association are about ready for distribution. These will be sent only to members in good standing.

New 1500 Volt Electric Locomotives

For the Piedmont & Northern Lines

These locomotives are designed for heavy freight service, weight 63½ tons each, and will haul trains of 800 to 1,000 tons gross weight at 21 miles per hour.

Locomotives are designed to operate on 1,500-volt d. c. system, four 600-1,200-volt motors which are insulated for 1,500 volts are used in series and series parallel combinations.

A new feature of this locomotive is the centralized arrangement of control apparatus in center of cab.

The Piedmont & Northern Lines, Charlotte, N. C., are placing in commission six new 1,500-volt, direct current electric locomotives on the Greenville, Spartanburg & Anderson division of their system. These locomotives weigh 63½ tons, with all the weight on drivers, have the box type of cab extending nearly the entire length of the underframe and are designed for heavy freight service. At the normal rating of the four GE-212 motors, with which each locomotive is equipped, operated on 1,500 volts two in series, will develop a tractive effort of 17,500 lbs. and a speed of 21 miles per hour. The locomotives will handle trains of 800 to 1,000 tons gross weight.

The Piedmont & Northern Lines comprise two main divisions, which, when entirely completed, will embrace 280 miles of track for limited and local passenger, express and heavy freight service. One division, operated by the Piedmont Traction Co., extends from Charlotte, N. C., to King's Mountain, N. C.

The entire line operates on 1,500 volts direct current. Energy is purchased from the Southern Power Company and is delivered from the transmission lines to two substations for the Piedmont Traction Co., one in Charlotte and the other in Gastonia.

The cab of the locomotive is of the all-steel box type and extends nearly the whole length of the underframing. Outside platforms of suitable width are left at each end for the switchman to handle the trolley poles and are protected by side end and hand or guard rails. In the interior the cab is open throughout as far as is consistent with the apparatus located therein. While the operating mechanism is grouped in the central section, it is not located in a compartment separate from the engineer's operating cabs. Convenient passageways run along each side and connect with the operating positions in each end. The cab is built up of steel channels and angles and sheet steel plates properly braced and riveted together, and is entered through center doors at each end.

The underframe or backbone of the locomotive consists of four 10-in. steel channels extending the entire length of the platform. These channels are tied together by heavy end frame box girder castings and bolster plates, each channel being riveted to the webs of the end frame castings and to the top and bottom bolster plates. The bolsters are built up of 18-in. by 1-in. plates, the top bolsters being carried across the platform and riveted to all four longitudinal sills. The two center channels are enclosed throughout with steel plates riveted to the under sills and carry the center-pin castings, which are bolted to them. The space between the center sills serves as a reservoir for distributing air from the blowers to the motors. Openings in the floor of this reservoir admit air from it through suitable intake pipes into the back end of each motor.

The two four-wheel trucks are a swivel type, designed for heavy freight work, and conform to MCB standards. The side frames are built of heavy rolled bars for top and bottom members with cast steel pedestals. The bolster, or center transom, is bolted rigidly to the side frames, and the entire weight of the truck framing is supported on heavy semielliptic springs hung by links to the double side equalizer bars, which in turn rest on the journal boxes. The journal boxes are a standard design with MCB bronze bearings and wedges. The wheels are solid rolled steel, 36-in. diameter, with MCB treads and flanges. The axles are forged open hearth steel, 6-in. diameter between the wheels and with 5½-in. by 10-in. journals. The air brakes are the combined straight and automatic type. The brake shoes are inside hung, and the brake rigging is proportioned for a brake shoe pressure of 85 per cent. of the weight on the drivers with 50 lbs. pressure in the brake cylinders. Hand brakes are provided to hold the engine in the yard in case of loss of air pressure in the brake cylinders.

Fig. 1. Interior of Locomotive, Showing Compressor. Note the Centralized Arrangement of Control Apparatus, Accessible from All Sides.

Taking up the electric equipment, the locomotive is driven by four GE-212 F, 600-1200 volt box frame commutating pole motors, insulated for operation on 1,500 volts. Each motor is geared to an axle. All the axles are therefore driving axles. A forged pinion is mounted on each armature shaft and meshes into a corresponding solid steel gear mounted on the axle. The gear ratio is 65 to 18 teeth, making 3.61 gear reduction. The continuous capacity of each motor is 200 amperes under forced ventilation, and 269 amperes at the one hour rating. For the complete equipment of four motors on a locomotive, this is equivalent to a continuously sustained tractive effort of 11,200 lbs. at the rail head.

The motor is enclosed and is designed especially for locomotive service. Through the method of forced ventilation employed, air is circulated over the armature and field coils, over and through the commutator, through longitudinal holes in the armature core, and thence exhausted through openings in the bearing head. A

large volume of cool air is thus distributed effectively throughout the motor, which keeps all parts at a uniform temperature and greatly reduces the possibility of "hot spots."

The control equipment is the well-known Sprague-General Electric type M multiple unit control, arranged to operate the four motors in series and series-parallel connections. The pairs of motors with their respective resistances are all connected in series on the first point of the controller. The resistance is varied through six points and finally short-circuited on the seventh or running point. The pairs of motors are then operated similarly in series-parallel and all resistance is cut out on the twelfth point, which is the full speed running point. This provides control connections with 7 steps in series and 5 steps in series-parallel. The transition between series and series-parallel is effected without opening the motor circuit, and there is no appreciable reduction in tractive effort during the change. This smooth transition between control points permits operating the motors close to the slipping point of the wheels throughout the entire range of acceleration without sudden fluctuations of tractive effort. Two switches are provided for cutting out either pair of motors, so that the locomotive can then be operated with one pair of motors in the usual manner.

One of the new and distinctive features for a locomotive of this type is the convenient manner in which the apparatus is arranged in the central section of the cab, so as to afford ready and complete access to all parts for inspection, cleaning, adjustment or repair. The main motor rheostat boxes are mounted in banks in an enclosed sheet steel compartment in the cab center. This compartment extends from the floor to the roof and is accessible through doors opening into the passageways on each side. The floor in the compartment is open and it is surmounted by an open monitor deck. Thus there is a continuous draught of air rushing up through the compartment while the locomotive is running, which affords exceptionally good ventilation. The rheostats are formed of the usual cast iron grids assembled in frames and insulated with mica. This arrangement allows ample rheostat capacity for the locomotive, as there are eighteen resistance units included in the group.

At each end of the rheostat compartment and suspended from the roof of the cab in laterally enclosed steel frames, accessible through lift doors at the sides, are grouped the contactors and reverser. Beneath there are installed on the floor the dynamotor, blower and one of the air reservoirs in one end, and the two air compressors and the other air reservoir in the other end. All mechanism and circuits carrying 1,500 volts are thoroughly insulated and protected from accidental contact.

Fig. 2. 1,500-Volt D. C. Electric Locomotive. Note that All Weight is on the Drivers. The Locomotive is Designed for Heavy Freight Service to Haul Trains of 1,000 Tons at 21 Miles Per Hour.

The blower set for ventilating the motors has a capacity of 2,000 cu. ft. per minute, and is driven by a series-wound motor of the railway type. Air is taken from the exterior through a suction box with side louvres underneath the platform at the center. Current at 600 volts for the operation of the blower, and also the air compressors, the contactors and the lights, is furnished from a two-fifths tap taken from the dynamotor. The contactors are of the same general design as that employed in the standard 600-volt Type M control. The principal modifications are embodied in the greater insulation distances and more effective methods of insulating where the contacts and magnetic blow-outs make and break on the 1,500-volt circuit.

At the operating positions, in each end of the cab, are located the engineer's seat, controller, air brake valves, bell and whistle ropes, ammeter, air gauges, sander valves and other parts of the control apparatus that should be within immediate reach of the engineer. A tool box with the usual complete equipment of tools is also provided.

Current is collected by an overhead US-13 pantograph trolley, which is pneumatically controlled and can be put into service from either engineer's station by a manually-operated valve. The trolley is arranged for a minimum operating height of 14 ft. 6 in. and a maximum height of 22 ft. On some of the local lines which form the system, the overhead construction is not adapted for the pantograph trolley, and in order to operate over such lines, the locomotives are equipped with pole type trolleys and trolley wheels. Some of these local lines are operated on 600 and in some cases as low as 500 volts direct current. A change-over switch is installed for cutting out the dynamotor while the locomotive is operating on low voltage circuits, so that in such cases the current for the auxiliary

control and supply circuits is obtained direct from the trolley circuit. This change-over switch is protected by an automatic relay, which makes it impossible to connect 1,500-volt trolley current to the auxiliary circuits of the locomotive.

The main switch is provided with a powerful blow-out so that heavy currents can be handled without damage. There is also furnished a complete equipment of auxiliary switches, one each for controlling the lighting, compressor and blower circuits, two each for the headlight and control circuits, two motor cut-out switches already mentioned, and also two manually-operated main auxiliary switches for cutting around the 1,500-600 volt automatic relay. All switches that control 1,500-volt circuits are thoroughly insulated for this higher voltage.

Protection of the locomotive against short circuit is very complete. There is one main fuse for the trolley circuit, two fuses for protecting locally the circuits of the pairs of motors and smaller fuses for the auxiliary circuits. The main fuses are of the copper ribbon type and are fitted with hinged covers to facilitate fuse renewals. All fuse boxes are provided with powerful magnetic blow-outs, energized by current passing through the fuse to insure proper rupture of the arc. The main fuse box is located as near as possible to the overhead trolley in order to protect the wiring circuits near the source of supply. An aluminum cell lightning arrester is also installed in the cab.

The locomotive is equipped with standard luminous arc headlights fitted with semaphore lenses. The brackets and plugs are arranged so that one headlight may be installed on each end or two on either end, as desired. Trolley retrievers are used for the pole collectors, and the edge of the cab roof is provided with projecting guard rails to prevent the trolley rope from cutting on the edge or catching in the lamps. The ammeter located at each engineer's station, indicates the current in the circuit of one pair of motors, and with the air gauges is illuminated by a gauge light connected in the headlight circuit, so that the headlight switch turns on simultaneously the headlight and gauge lights in corresponding ends of the locomotive.

The principal data and dimensions applying to the locomotives are the following:

Length inside of knuckles	37 ft. 4 in.
Length over cab	27 ft.
Height to trolley base	13 ft.
Width overall	9 ft. 7 in.
Total wheel base	26 ft. 8 in.
Rigid wheel base	7 ft. 2 in.
Track gauge	4 ft. 8½ in.
Tractive effort at 25 per cent. coefficient	30,000 lbs.
Tractive effort at one hour rating	17,500 lbs.
Tractive effort at continuous rating	11,200 lbs.
Weight per driving axle	31,750 lbs.
Weight electrical equipment	37,500 lbs.
Weight mechanical equipment	89,500 lbs.
Total weight on drivers	127,000 lbs.

Telephone vs. Telegraph

In Steam Railroad Operation

M. H. Clapp, Supt. of Tel., Nor. Pac. Ry.

Telephone circuits cost more to install and operate than telegraph, but they effect a saving both in operating cost of the telegraph department, and in making it possible to move trains over the road more rapidly.

The relative advantages and disadvantages of telephone and telegraph may be summarized as follows:

In Favor of the Telephone. Universality, saving of time, rapidity of transmission, psychological effects, promptness in raising offices, no necessity of specially trained operators, saving in expense of railroad operation, and best operation of circuit in heavy weather.

In Favor of Telegraph. Flexibility in handling circuits, simplicity in installing, maintaining and operating, circuit best adapted for long distances, effects of distance in transmission, saving in cost of installation and maintenance, and the standard of maintenance.

The author believes that telephone will eventually be used for all train dispatching, local message and business requiring conversation, but that the telegraph will continue to be used for long distance message work.

While trains were handled for short distances, principally in and about terminals, beginning back in the early nineties, it was not until the latter part of 1907 that any real attempt was made to handle trains on long stretches of main-line track by telephone. The Chicago, Burlington and Quincy road was one of the first to use telephone train-dispatching circuits on their main lines, and by the latter part of 1908 this company had a considerable mileage of its lines dispatched by telephone. The principal railroads in the East and the middle West at once began to install telephone circuits, so that at present there are some 70,000 miles of railroad in the United States dispatched by telephone. The use of the selective-ringing telephone circuit for the dispatching of trains was soon followed by the use of the same kind of circuit for the handling of messages. The growth of the telephone message circuit has, however, been very much slower than that of the dispatching circuit. The primary reason for this is the fact that the telephone message circuit does not meet the conditions on the average railroad to the same advantage as the dispatching circuit, there being more complications to meet than in the case of the dispatching circuit. In general, the message circuit requires a considerable amount of traffic to justify its use. However, it will only be a question of time when all telephone dispatching circuits are parallelled by telephone message circuits.

A Typical Railroad Telegraph System.

The outside and inside plants used by different railroads necessarily vary to a large degree on account of the different sizes, resources, locations and conditions of the railroads served. A description will be given, therefore, of the system on one of the large transcontinental railroads with which the writer is most familiar.

The average cost per mile (1.6 km.) for furnishing and erecting a No. 8 B.W.G. iron wire, including insulators, tie wires and pins, is about $25.00. This wire makes a very good telegraph circuit up to 400 miles without any intermediate offices. At this distance the wire can be worked either singled, duplexed or quadruplexed. With intermediate (way) offices on the line the above-mentioned distance would be cut down to about 200 miles. The matter of line insulation has a very important bearing on the distance that an iron wire or, in fact, any telegraph wire can be successfully operated. The distances given above assume a high grade of insulation.

The cost per mile for providing and erecting No. 9 B. & S. gage copper wire including insulators, pins and tie wires, varies greatly with the price of copper, but

*Abstract of paper presented at the March, 1914, Meeting of the American Institute of Electrical Engineers, New York.

assuming fifteen-cent copper, it would be, on the average, about $38.00.

The equipment of a telegraph office is comparatively simple and needs no description. The following costs will be of interest in comparison with the cost of telephone equipment.

A way station can be cut-in on a telegraph wire, including the battery (gravity) in the office, at a total average cost of	$ 12.00
A switchboard (peg type) large enough to take care of ten wires, in and out, can be provided and installed at a cost of	42.00
The cost of providing and installing a twenty-five line Western Union switchboard, with twenty wires cut in and out, and eight sets of telegraph instruments with necessary tables and battery, is about	140.00
Nineteen-conductor cable (No. 14 A.W.G.) suitable for connecting the wires from the line into the offices, can be provided and installed at an average cost of per foot	.30
The average cost of providing and installing a quadruplex set would be about	200.00
The average cost of providing and installing a single-line repeater set would be about	50.00

At terminals, of course, more apparatus is necessary than at the way-stations along the line. However, a cost of $400.00 would provide and install the equipment in almost any terminal or relay office along the line, except the very largest.

Principal Advantages of the Telegraph.

The principal advantages of the telegraph are its simplicity and its small cost, both as regards installation and in maintenance; this statement being made, of course, in comparison with the telephone. There are no very complicated circuits in connection with the telegraph, especially at the great majority of the offices along the line. The ordinary lineman has no difficulty in learning how to install and maintain sets of telegraph instruments, and with a little experience, he is able to install duplex and quadruplex apparatus, and Western Union peg switchboards. In general, no particular care is necessary in running telegraph circuits, with respect to one another, in order to avoid induction either in the offices or on the line. In making the last statement, however, the author fully appreciates that telegraph circuits have been seriously interfered with by induction in certain cases; the conditions in mind are those which exist, as a rule, on the great majority of railroads where the telegraph is used. Also, a telegraph circuit will operate under defective maintenance conditions, such as loose connections, unsoldered joints, defective office and cable-box wiring, high resistance in series with circuit, etc., where a telephone circuit would absolutely fail. In other words, the telegraph circuit usually has a considerable amount or margin in operation and will stand a large amount of neglect and abuse. The cost, as already indicated, is small for both line wires and office equipment, and while copper wire is used to some extent, iron wire serves the purpose in a great many cases where it would not be possible to use it in connection with the telephone. The telegraph, also, has the advantage of being a very accurate means of communication. A telegraph sounder makes very clear and distinct signals, and to an expert operator, there is no question as to what has been transmitted; and, if the wire is working at all, the distance is not must of a factor, because the sounder is in a local circuit.

Disadvantages of the Telegraph.

The great disadvantage of the telegraph is its lack of universality. It requires a specialist in order to operate it; that is, an operator who has spent a considerable amount of time, years in some cases, in order to qualify for the work. When carrying on a telegraphic correspondence, one is always working through some one else, never directly. This condition is satisfactory in handling some kinds of business, but not for all kinds. The train conductor out on the line can, in the case of an accident, send messages by telegraph to his superior if there is a telegraph office near at hand in which operators are on duty, and accomplish certain results; however, if he can talk directly with his superintendent, a great deal more can be accomplished. The same is true of the section foreman out on the line, the superintendent in his office, and other employes on the division.

This disadvantage of the telegraph is especially noticeable when one attempts to discuss any subject over the wire by telegraph, even between expert operators. The telegraph is at its best in handling messages that are comparatively brief, making definite statements or reports or answering definite questions. As soon as one attempts to ask several questions on different phases or points of a subject, in other words, attempts to discuss it, the telegraph becomes a comparatively slow means of communication.

There is, also, the trouble experienced in obtaining operators, which in recent years has become a serious problem, especially when times are prosperous. A railroad which depends at present entirely upon the telegraph has considerable difficulty in securing operators of any kind, without much regard for their ability.

The Railroad Telephone Plant.

The outside plant necessary in connection with the telephone is substantially the same as that required for the telegraph, except that in practically all cases copper wires are used.

The cost of telephone circuits for use between the exchanges along the line depends, of course, on the kind and the size of line-wire used. The cost per mile of a No. 9 A. W. G. copper circuit in place, on the basis of fifteen-cent copper, is about $75.00. The cost per mile of a No. 6 A. W. G. copper circuit on the same basis would be about $150. The latter circuit would give, under ordinary conditions, satisfactory telephone transmission up to 1,000 miles, while the former would be satisfactory up to about 500 miles (804.6 km.).

The telephone dispatching and message circuits are the most interesting and peculiar to the railroad service. The provisions of a means of selectively signaling the different stations along the line was a problem that took some time to solve satisfactorily. These selectors have different designs and principles of operation. In general, the selection is made by a step-by-step mechanism which responds to a certain number of pulsations or combinations of pulsations sent over the line, making it possible to arrange a large number of selective combinations, and thus signal any given station at will, without disturbing the others. At the stations along the line a special form of telephone set is installed for the use of the operators. These sets have a certain combination of apparatus and wiring that provides a so-called "booster" effect in transmission. This is secured by a switch which is so connected in the circuit that when the operator is talking, the receiver is short-circuited, and when the operator is listening, the receiver is connected directly to the line and the transmitter disconnected.

The cost of providing a selector circuit ready for operation under average conditions is as follows:

Cost per station of providing and installing the selector and telephone equipment, protectors and wiring, both outside and inside of the offices, $80.00.

Cost of providing and installing the necessary telephone and selective apparatus, including the battery, in the office of the dispatcher, $250.00. Assuming that a

telegraph pole line is already available, the cost of a suitable telephone circuit has already been placed at $75.00 per mile, so that the cost of providing and installing a selective telephone circuit along 100 miles (160.9 km.) of railroad, where there are thirty offices to serve, would be a little over $10,000.

A telephone circuit as described above can be used either as a dispatching circuit or as a message circuit.

Two very useful and time-saving auxiliaries which are available with a telephone system are installations of telephones in booths or boxes along the railroad right-of-way at so-called "blind sidings" (where no regular operators are employed, and where there may be not even a station building) and portable telephones for the use of the train crews. Telephones of these types can be used to great advantage by the trainmen in handling the many emergencies that arise, and are also of material assistance to the dispatcher, in reducing train delays. Order-forms for use of the trainmen are usually provided along with the telephones installed in booths or boxes and, in some cases special forms of registers are provided in which the order forms are placed so that three copies can be made of all orders transmitted to the trainmen, one copy in each case being given to the engineman, the second copy to the conductor, and the third copy remaining in the machine as a record.

The cost of a booth installed along the right-of-way, with the necessary telephone apparatus, depends on how elaborate an installation is desired; a very substantial and satisfactory installation can be provided for $90.00, but this can be reduced to possibly $30.00. A good portable telephone can be purchased for $12.00.

In addition to the uses already described, there are various miscellaneous ways in which the telephone can be used on a modern railroad, in the observation cars of limited trains, in freight sheds and in freight yards so as to provide a means of ready communication from one point to another, etc.

The method employed in handling train orders by telephone contains some points of interest. All figures or names of stations occurring in the orders are spelled out letter by letter, both in the giving of the order and in all repetitions; also, in handling a "31" order,[1] the name of the conductor is spelled out. The dispatcher writes the order in his train-order book at the same time that he telephones it to the operator or operators on the line. Each operator who receives the order repeats it back to the dispatcher, the dispatcher underlining each word or number as repeated. In operating a message circuit, the same general practice of spelling out words and figures is followed as in the case of the dispatching circuit.

In the author's opinion, specially trained men should always be employed to maintain the telephone station equipment, although on some railroads the section linemen are required to maintain the telephone equipment; the last plan, however, produces in most cases indifferent results. In order to maintain properly four selective telephone circuits, having an average length of 100 miles each, at least one telephone inspector should be provided at a monthly rate of $85.00 with expenses, and there should be additional force if there are many telephones maintained at different "blind sidings" along the line, or special apparatus installed at various terminals, private-branch exchanges, etc. All of this expense is practically in excess of what is necessary to maintain the telegraph to handle the same work, although, as already indicated, the telephone handles a great many transactions that were never attempted by telegraph.

[1] A form "31" order requires the signature of engineman and conductor, whereas a form "19" order does not: see "Standard Code," of the American Railway Association.

Comparative Advantages of the Telephone.

The advantages of the telephone are many; some direct, some indirect and some psychological. The first and most important in the author's opinion is that it permits direct dealing between the parties desiring to transact business. The superintendent can talk directly with his subordinate; the chief dispatcher can talk directly with the trainmen out on the line, and any two employes can deal directly with one another, if the proper telephone facilities have been provided. This is what might be termed the universality of the telephone as compared with the telegraph; every one from the president to the section foremen can use the telephone directly.

The telephone, compared with the telegraph, is a great time saver on account of its speed of transmission. Train orders can be handled more rapidly by telephone than by telegraph. This is due to the fact that the orders can actually be transmitted faster over the telephone; also, to the fact that the operators along the line can be made to answer the calls on the telephone bells quicker than their calls on the telegraph.

By the use of the telephone, the field from which dispatchers and operators can be recruited is naturally broadened. It is no longer necessary on a railroad where the telephone has been installed with a sufficient number of circuits to keep the service intact, to depend on telegraph operators, in other words, specialists. There is, for example, one division on the Pennsylvania Railroad where out of about 400 operators' positions along the line, it is necessary to fill only eight of them with telegraph operators. This is a very important point for consideration in these days when, as already stated, the supply of telegraph operators is not equal to the demand. Also, it is possible to use as a dispatcher an employe other than one who has obtained his experience in the telegraph or telephone service, as, for example, a freight or passenger conductor.

While a telephone circuit is, in most cases, more susceptible to outside influences than the telegraph, experience shows that in heavy weather, heavy fog, mist, rain or snow, less trouble is experienced with the telephone than with the telegraph; and the telephone is affected only to a small degree by earth currents or by the aurora borealis.

Finally, we have for consideration the saving in the operation of the railroad by the use of the telephone. Unfortunately, it is hard to show in all cases a saving, because many of the best-known economies are more or less intangible. One is generally sure that he is saving time by using the telephone, and it seems at least a fair assumption that there is a corresponding money saving.

In the way of direct saving, the ability of the dispatcher to get his trains over the division quickly, thereby economizing in operating expenses, is the most evident, and easiest to understand. This is especially noticeable in the amount of overtime that can be saved in the pay rolls of the trainmen and the enginemen. As it is conservatively estimated that the trains can be handled over a division from 10 per cent to 20 per cent more rapidly by telephone than by telegraph, an approximate estimate of the overtime saved can be prepared by considering a certain operating division before and after the telegraph is replaced by the telephone. For example, on a certain division where the Northern Pacific is now installing the telephone, both for handling trains and for handling the messages along the line, it has been estimated that a saving of about $200.00 per month will be made in overtime paid to trainmen and enginemen.

In some cases, a direct saving can be made by using a smaller number of dispatchers when handling a given section of railroad by telephone, as compared with the telegraph. For example, there is a division on the North-

ern Pacific which is made up of four consecutive districts, having an average length of a little over 100 miles each. Part of the year, the four districts can be handled by using two telephone dispatching circuits; but when there is considerable business on the railroad, four dispatching circuits are used. It would be necessary with the telegraph, to handle the four districts by using four circuits at all seasons of the year. As it requires three dispatchers to handle one dispatcher's circuit during the entire twenty-four hours, and as the salary of a trick dispatcher is $155.00 per month, the abandonment of any of these positions even for a part of the year is a very desirable thing from the standpoint of saving in expenses.

Disadvantages of the Telephone.

The principal disadvantage of the telephone as compared with the telegraph is its cost of installation and maintenance. However, these increased costs are overcome by the savings that are made possible. Another disadvantage is that the telephone, in the present state of the art, is not adapted, on account of excessive cost, for use on the railroad for any considerable distance. While there is a circuit about 1,000 miles in length in operation on one railroad in this country, at least, this circuit is used entirely as a talking-circuit and is not used for message work. It requires a good margin of transmission to handle messages over a telephone circuit and, according to the author's experience, a circuit equating to more than 26 miles of standard[2] cable should not be used in railroad service; at least, not in connection with handling trains or messages.

While it is possible to construct a telephone circuit 2,000 miles (3,218 km.) long, or even longer, that would have the proper transmission efficiency, it will apparently be some time before a railroad can justify such a circuit, from the standpoint of first cost and maintenance expense, and benefits derived. The telegraph will probably continue to handle the messages for the long distances, such as 500, 1,000, or 1,500 miles (804, 1,609 or 2,414 km.) for a considerable time to come.

The telephone is not as flexible as the telegraph when making patches in cases of trouble on the regular wires.

The telephone requires a much higher efficiency of maintenance than the telegraph. This is not, strictly speaking, a disadvantage. In fact, the telegraph wires and apparatus should be maintained as well as the telephone system, but in practice this is not done except in very few cases.

Applications of the Telephone

As yet very few railroads are using the telephone as much as they could or should. Because many of the economies with the telephone are more or less intangible, railroad managers are rather cautious in authorizing its wholesale installation. They are usually ready to authorize telephone dispatching circuits, as the savings from them are more easily understood than in other applications. In the author's opinion, the up-to-date railroad of the future will handle its operating divisions entirely by telephone, the telegraph being used only for message work for long distances between the terminals and the general headquarters. On the divisions, the typical way office will have no telegraph instruments, and will depend entirely upon the telephone for handling all messages. At all terminal points and important offices along the line, private-branch exchanges will be installed, which will be connected with each other by means of talking circuits, so that any two employes on the same division or adjacent divisions can communicate with one another easily and quickly. Telephones will be installed in booths or boxes along the right-of-way at frequent intervals, such as every half-mile, and the necessary lines and apparatus provided.

The local use of the telephone has been well developed in a great many places, and the same is true of its use in dispatching trains; but its universal application as a means of communication, and its substitution for and its use as an auxiliary to the telegraph, have only in a very few instances been carried to a logical conclusion.

Summary.

The following summary presents the respective advantages and disadvantages of the telegraph and the telephone.

The advantages of the telegraph are: (1) Flexibility in handling circuits; (2) simplicity of installation, operation and maintenance; (3) best adapted for long-distance service; (4) least affected by distance, in respect to transmission efficiency; (5) low cost of installation and maintenance; (6) the necessary standard of maintenance is not difficult to secure.

The advantages of the telephone are: (1) Universality; (2) saving of time; (3) rapidity of transmission or dispatch of business; (4) psychological effects; (5) minimum delay in getting offices to answer calls; (6) lack of necessity of trained specialists to operate the service; (7) saving in total expenses of railroad operation; (8) minimum impairment of transmission efficiency in heavy weather.

[2] Standard cable has a resistance of 88 ohms per unit (No. 19 A. W. G. metallic) and a mutual capacity of 0.054 microfarads per mile.

Notes on Electrical Equipment for Panama Exposition

Working drawings are now being made of the device to be used for suspending the jewels from the various buildings. A metal ring one-eighth inch wide will encompass the jewel on the outer edge at an angle and a second holder at the back will bring a small mirror against the apex of the jewel. It is estimated that the brilliancy will be increased more than forty per cent by the use of this mirror.

The jewel is hung by small handle with a one-quarter inch hole on a one-eighth inch hook which permits of free movement in any direction and practically amounts to point suspension.

As has been explained before, the jewels are forty-seven millimeters in diameter and are molded from an exceptionally hard flint glass in Austria and are afterward farmed out to the peasantry to be hand-cut and polished. The cut is an imitation of a well-known cut of diamond.

Complete orders have been placed for all auxiliary equipment required for the operating of the three main D. C. generating stations for the control of D. C. power for exhibitors and decorative lighting.

An order was placed during the week with the Wheeler Reflector Company, of Boston, Mass., for 2,154 reflectors varying in size from 7 to 11 inches. They are to be made of steel with lacquered aluminum finish and will be used in the various exhibit palaces.

Experiments are now being made to determine the extent to which it will be advisable to use electrical substitute for fire-work displays. Imitations of waterfalls will be used which will show gold and silver showers in the day and at night these will be displayed to advantage by searchlights.

The department is developing a new form of receptacle for use in gala and festive lighting. These are in the form of Mission bells and more than 25,000 will be used in decorative lighting. Special lamps will be grouped so as to imitate the various forms of fruits and flowers. The lamps to be used in this feature work will be similar to those in common use for Christmas tree lighting.

High Speed Electric Locomotives

Oakland, Antioch & Eastern Ry.

Sixty-two-ton electric locomotives replace the multiple unit car system on large interurban line, to handle the heavy through passenger traffic. Locomotives, designed for 1,100-volt d. c. service are capable of developing a speed of 56 miles per hour when hauling 5 cars of 37½ tons, and 60 miles per hour hauling 3 cars.

Locomotives have new centralized arrangement of control apparatus in center of cab, which provides access from all sides, as well as compact and convenient arrangement of equipment.

Business has increased so rapidly since the opening of the Oakland, Antioch & Eastern Railway that in order to cope with the heavy through passenger traffic between San Francisco and Sacramento it has been necessary to place in operation two 62-ton electric locomotives. The use of electric locomotives for hauling passenger trail cars instead of using multiple-unit cars is a new departure in the electric railway field, which should interest steam railroad men. The phenomenal growth in traffic mentioned above is largely due to the opening up of new territory which has been heretofore practically inaccessible to the Bay Cities except by long roundabout steam route.

The locomotives are of the 2-4-0 articulated truck type and each is equipped with four Westinghouse No. 308-D-7, 250 h. p., 600-1200-volt commutating pole motors and type HLF unit switch control.

Each locomotive when operating at a balancing speed of approximately 56 m. p. h. is capable of hauling a train of five steel passenger trail cars, weighing 37.5 tons each, on a level tangent track with 1,100 volts direct current on the trolley. With only three of these cars, one of these locomotives under the same track conditions is able to attain a balancing speed of about 60 m. p. h.

Mechanical Parts

There are two articulated trucks each having six wheels, four of which are drivers, making a total of eight drivers per locomotive Each group of wheels, consisting of two pairs of driving wheels and one two-wheeled radial truck, has an independent frame. These two truck frames are connected together with an articulation link. The cab is mounted on a separate frame which is supported on the truck frame by 8 spring loaded friction plates, no draw bar pull being transmitted through the cab. The cab center pins carry no weight and are used simply to maintain the position of the cab with respect to the trucks.

In negotiating curves, the inside buffers are compressed, thus tending to restore the alignment of the frames after the curve has been traversed. These buffers, being in contact at all times, also help to promote steady riding when passing over rough tracks.

The center pins, which hold the cab frame in alignment with the trucks, are 14 feet 8½ inches apart. One of these pins is allowed a limited amount of longitudinal movement in the center plate on the cab frame. This is in order to compensate for the varying distance between truck centers when the locomotive is traversing curves, and to relieve the cab frame from buffing shocks.

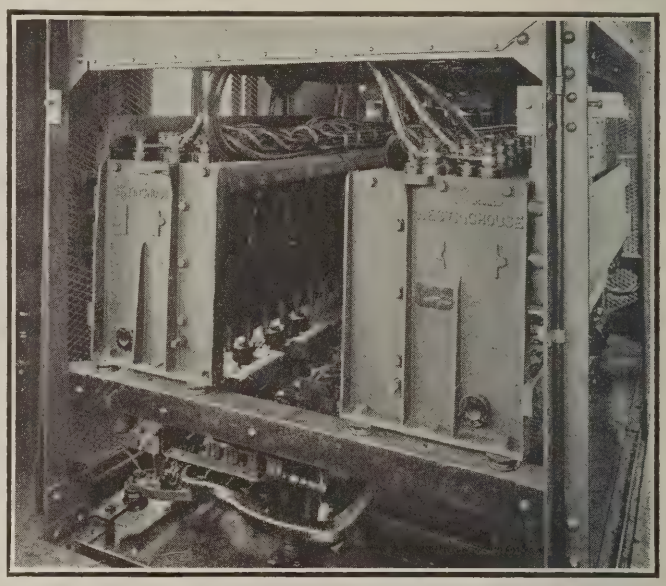


Fig. 2. Control Apparatus in Center of Locomotive Cab.

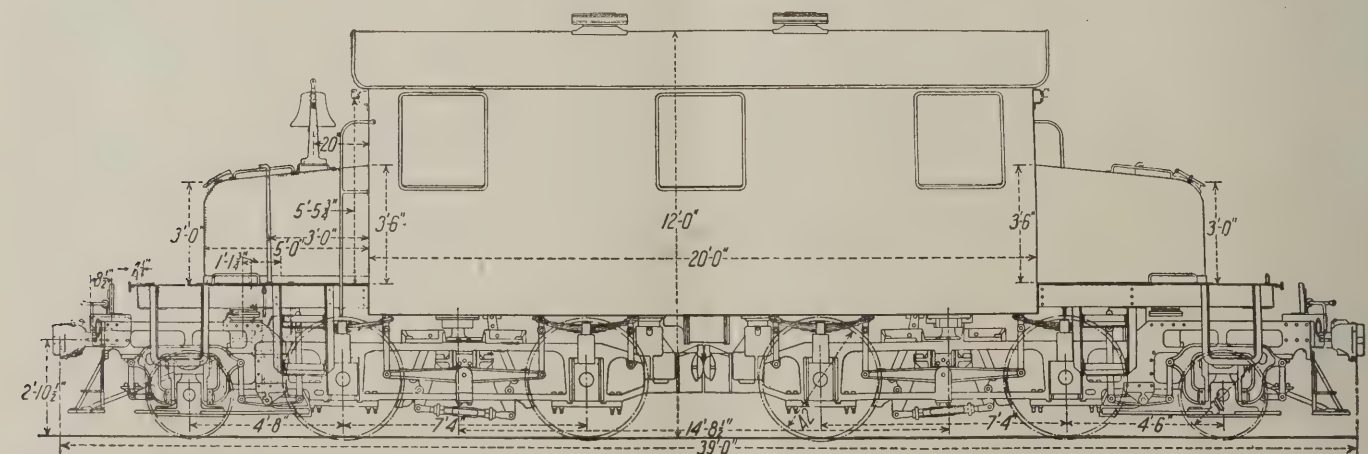


Fig. 1. Side Elevation of High Speed Electric Locomotive. Note the Guiding Trucks at Either End, Cab is Pivoted Over Each Main Truck, Motors Geared Direct to Axle.

These locomotives are equipped with head lights, pilots, and automatic couplers at each end. The couplers have radial draw bars, which are provided with centering springs. This is an important feature, as in service these locomotives traverse curves of 100-ft. radius. The equipment also includes air sand-

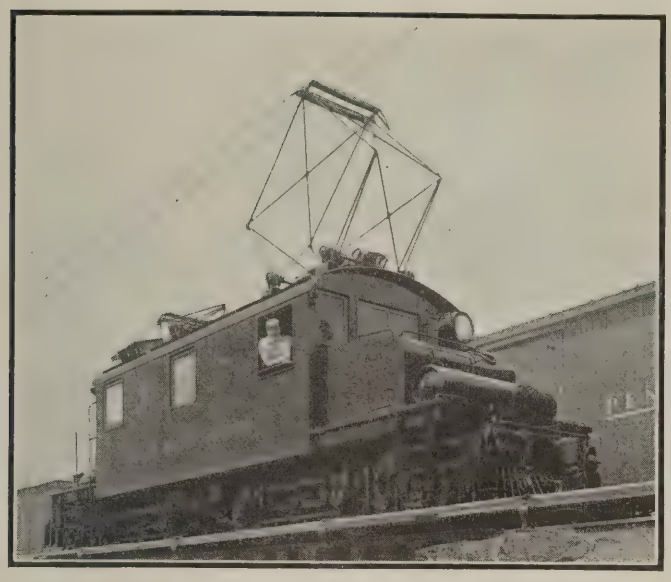


Fig. 3. 1,100-Volt Electric Locomotive.

ers front and back and combined air and hand brakes on all driving wheels. One standard locomotive bell and two air whistles are supplied. The driving wheels have cast iron centers with steel tires shrunk and bolted, while the truck wheels are of rolled steel.

The principal dimensions of these locomotives are as follows:

Gauge	4 ft. 8½ in.
Wheel base, rigid	7 ft. 4 in.
Wheel base, total	31 ft.
Driving wheels, diameter outside	42 in.
Driving wheels, diameter center	37 in.
Driving journals	5 in. x 9 in.
Truck wheels, diameter	30 in.
Truck journals	4½ in. x 8 in.
Width overall	10 ft.
Height to top of cab	12 ft.
Length center to center of coupler knuckles	39 ft.
Weight on driving wheels	88,000 lbs.
Weight, total engine	134,000 lbs.

Control

The control for the traction motors is of the Westinghouse unit switch field type, similar to the type HL, except that the field control takes care of the extra field tap of the motors. With this type of control the time of acceleration during which running on resistance is necessary is considerably reduced.

Westinghouse field control has been extensively used not only for locomotives but also for street and interurban cars. The Pennsylvania R. R. and the N. Y., N. H. & H. R. R. passenger locomotives are arranged for field control.

The control equipment is mounted in a grounded expanded metal cage which protects the apparatus and yet allows it to be accessible for maintenance and inspection, thus greatly assisting to insure reliable operation and continuity of service.

In the right-hand corners of the cab are mounted the master controller, engineer's brake valve and sander valves. These locomotives are designed for double end operation. The general arrangement of apparatus is shown in Fig. 2.

Forced ventilation is supplied by blowers mounted on the extended shaft of the dynamotors.

The advantages of this centralized arrangement are numerous, but the chief advantage is that all the control apparatus is assembled compactly in one part of the locomotive instead of being scattered in different locations. The switch groups are located in such a position that they are readily accessible from all sides and they are at such a height that a man can get at them freely without working in a cramped position, or inside the hood.

Motors.

Each locomotive is propelled by four 250-h.p. motors. These motors are of the commutating-pole box frame type arranged for field control.

The field of each motor has four coils, each of which is divided into two parts, one having a greater number of turns than the other. However, these two coils are insulated from one another, but bound so as to make one unit. Since these motors are of the field control type the field coils are connected in two circuits, one made up of the coils having the larger number of turns and the other of the coils with a similar number of turns. In accelerating where a large tractive effort is needed, both these field circuits are connected in series, thus giving a strong field; and after the motors get up to speed, the circuit containing the coils with the fewer number of turns is cut out; then the motors operate on short field.

Two dynamotors are mounted on each locomotive. These operate the compressor and blowers and supply the required amount of 600-volt direct current for lighting the passenger cars, the locomotive, headlight and for operating the control. Each compressor has a capacity of 35 cubic feet of free air per minute.

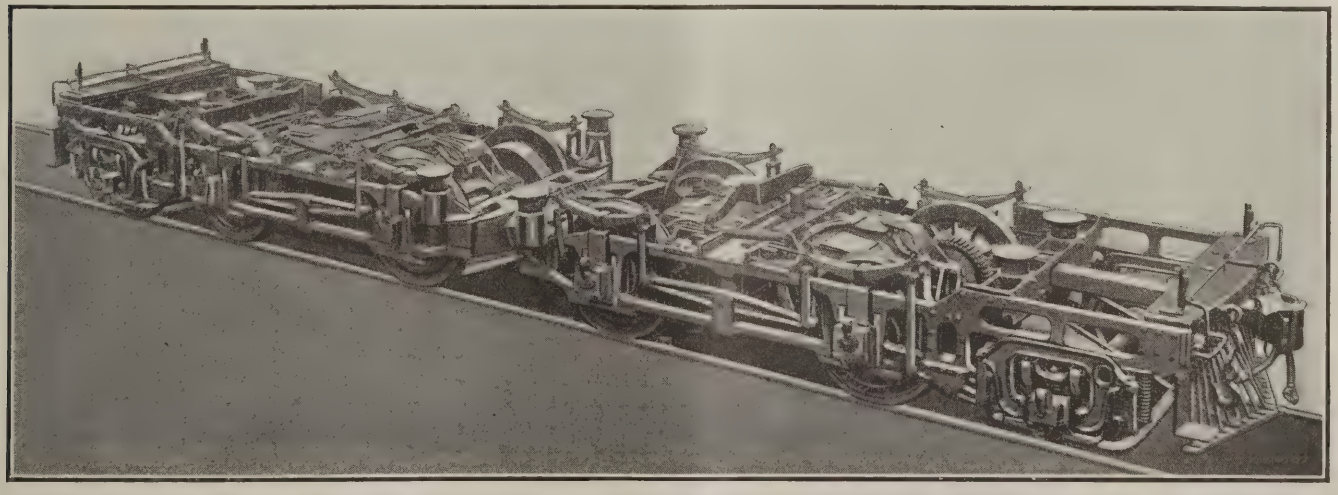
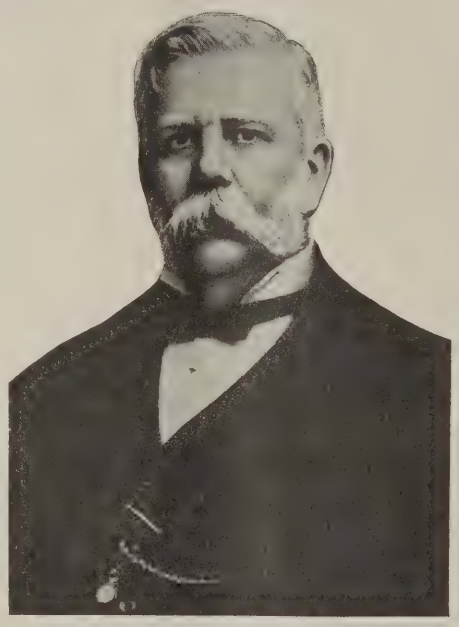


Fig. 4. Running Gear of High Speed Electric Locomotive with Cab Removed. Note the Eight Pedestals for Supporting Cab Frame.

George Westinghouse

George Westinghouse, the famous inventor and engineer, died of heart disease at his New York City residence on Thursday, March 12. His health had been failing for some time and consequently his death, though a great shock to his thousands of friends and acquaintances all over the country, was nevertheless in a measure anticipated. He was born at Central Bridge, Scholarie County, N. Y., on the 6th of October, 1846. Mr. Westinghouse's father was an inventor, who, in 1856, removed his family to Schenectady, N. Y., where he established the Schenectady Agricultural Works. The boy attended the public and high schools of the town, spending much of his leisure time, after studies, in his father's machine shop. What to other lads would have been regarded as irksome and confining, young Westinghouse found to be a source of amusement and instruction. Before he was fifteen he invented and made a rotary engine, and passed at an early age the examination for the position of assistant engineer in the United States navy. In 1865 he invented a device for replacing railroad cars upon the track, which, being of cast steel, was manufactured by the Bessemer Steel Works, at Troy, N. Y.



George Westinghouse.

The Air Brake.

Going to Troy one day, a delay caused by a collision between two freight trains, suggested to Mr. Westinghouse the idea that a brake under the control of an engineer might have prevented the accident. His first thought was an automatic brake attached to the couplers, which was unsuccessful. This was followed by steam, which proved also to be unsatisfactory, because by the time it reached the brake from the engineer's cab it lost its power.

At this point Fate seems to have entered his life. In the pages of a magazine he had subscribed to through the solicitation of a young girl, he saw an account of the use of compressed air in digging the Mont Cenis tunnel, 3,000 feet under ground. Instantly the inventor saw the light.

The inventor began to think over the matter, and, after much further study and investigation, the use of compressed air further impressed itself on him. Drawings of the air-pump, brake cylinder and valves were made, but considerable time elapsed before a practical trial of the brake was obtained. The first patent was issued April 13, 1869, and the Westinghouse Air Brake Company was formed on the 20th of July following.

Many changes and improvements were being made in the brake all the while, the business flourished, and the manufacturing works, begun in 1869, were completed in 1870. In 1870 Mr. Westinghouse went abroad to introduce the air brake in England—a difficult problem, as the trains in Europe had hand brakes upon only what were known as "brake vans," there being no brakes upon the other vehicles. Not only did this require the spending of seven years in Europe, between the years 1871 and 1882, but it taxed his inventive ability considerably to meet the new conditions of railroad practice.

The Automatic Brake.

In the meantime Mr. Westinghouse invented the "automatic" feature of the brake which overcame the imperfections in the first form, and removed the danger from the parting of trains on steep grades. In 1886 he invented the "quick-action" brake, the improvement being made in what is known as the "triple-valve." By this valve it became practicable to apply all brakes on the train of fifty freight cars in two seconds. The automatic and quick-action brakes are regarded by experts as surpassing the original brake in ingenuity and inventive genius, being not mere improvements, but distinct inventions of the highest class, unique and remarkable.

Signal Work.

About 1880 Mr. Westinghouse became interested in the operation of railway signals and switches by compressed air, and soon after there was developed and patented the system now manufactured by The Union Switch & Signal Company. The "Pneumatic Interlocking Switch and Signal Apparatus," whereby all the signals and switches are operated from a given point, using compressed air as the motive power, and electricity to bring that power into operation, has been successfully introduced in Boston, Jersey City, Philadelphia, Chicago, St. Louis and many other places.

The Electric Company.

In 1886 the Westinghouse Electric Company was formed for the manufacture of lamps and electric lighting apparatus, Mr. Westinghouse having become interested in the subject. The business rapidly developed and in 1889 and 1890 this company absorbed the United States Electric Company and the Consolidated Electric Light Company. In 1891 all these properties were reorganized into the Westinghouse Electric & Manufacturing Company, which owns extensive works at East Pittsburgh, employing over 22,000 people.

In 1892 Mr. Westinghouse secured for the electric company the contract for the electrical equipment of the World's Fair at Chicago, and in 1893 the contract for the large generators at Niagara Falls, both of which marked epochs in the progress of the electrical industry.

In 1895 the electric company outgrew the small quarters at Garrison Alley and moved to East Pittsburgh, and the same year works of the British Westinghouse Company were established at Manchester, England.

Alternating Current Transmission.

Mr. Westinghouse rendered an invaluable service to the electrical development of the world, when, in spite of opposition, ridicule and all the unfair efforts to crush his alternating current system, he remained steadfast in his belief that this class of high-tension transmission would make distant electrical distribution possible. This system his engineers developed, and incidentally in this connection secured Nicola Tesla, in 1887, who invented the alternating current induction motor. The world today lighted by distant waterfalls and central stations, now recognize its debt to Mr. Westinghouse's foresight and perseverance.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

All back lessons of this course will be furnished at 5 cents each, which will also include, (1) *Railroad Electricians' Club,* (2) *A B C Car Lighting Course,* (3) *Practical Stunts, and* (4) *Question Box, as published that particular month.*

Lesson No. 11--Question Box

24.—Does the expression, "Elongation per cent in one foot," in the wire table, mean the per cent that the wire will stretch before breaking when put under test? What is the meaning of "Turns per lineal inch, cotton covered?"

The term "Elongation per cent in one foot" means the per cent stretch of the wire for a one foot sample before breaking; that is, if a sample of wire 12 inches long was placed in a testing machine and pulled until it broke it might be stretched to 13 inches just at the breaking point. This would then be stretched 1 inch, which is $1 \div 12$, or 8.3%. "Turns per lineal inch, cotton covered," refers to the number of turns of this wire which could be wrapped on a spindle one inch long when the wire is insulated with a cotton covering.

25.—Why could not conductors used in cables be given a coating of celluloid lacquer as an insulation to take the place of paper? This lacquer is claimed to have a high resistance.

The celluloid lacquer would be seriously affected by temperature changes, as it is subjected to both heat and cold. Once a fire was started on any of these conductors coated with the celluloid, there would doubtless be a great deal of trouble caused, as celluloid is highly a great deal of trouble caused, as celluloid is highly inflammable and often explodes with violence. In making splices, great care would have to be taken to remove all of this lacquer, or else a high resistance joint would be obtained. It would not be as flexible as the paper and would be subject to corrosion.

26.—What advantages are gained by or what is the purpose of using condensers?

Condensers are used largely in telegraph and telephone equipment for performing certain functions in the circuits. Their use and method of connection will be fully explained in a later pamphlet on this apparatus, as well as tests for them. So far as the passage of direct current through them is concerned, they operate practically the same as an open circuit, but alternating current will pass through them readily.

27.—Can the amperage of a circuit be more than the voltage or can you have a greater flow of current than voltage?

This relation is explained by formulas in Lesson No. 1, showing the relation of these terms from Ohm's law. By applying equation No. 1 to any direct current circuit, the current in amperes can be readily obtained when the voltage and resistance are known. For instance, if there was a potential of ten volts in a circuit and the resistance was only one-fourth of an ohm, then the current would be forty amperes; when the voltage is the same as above and the resistance is increased to, say, one ohm, then from the relation shown in equation No. 1 the current would be ten amperes, and so on.

28.—If the "copper loss" is the amount of energy dissipated as heat in the circuit, what is the line drop?

The "line drop" is the loss in pressure, expressed in volts, between the generator or source of energy and the consumer's end. This is the pressure required to overcome the resistance, expressed in ohms, in the line wire. The "copper loss" is the loss in the line, expressed in watts, and is the product of the line drop, expressed in volts, and the current expressed in amperes. This is expressed by the formula $W = EI$, but as $E = IR$, then $W = I^2R$, which is the formula commonly used for finding the copper loss in the line wire.

29.—In pamphlet E-2 is described the "Leyden Jar." It reads as follows:

4th line.—"The capacity of a Leyden Jar depends directly upon the *area* of the plates, etc.," and further on it reads, "The capacity is not determined by the *thickness* of the plates." Mention is previously made only of a jar and the tin foil. What do the "plates" refer to?

The area of the plates mentioned has reference to the surface of the tin foil exposed to the glass jar. The *thickness* has reference to the same tin foil plates. The jar mentioned has reference to the glass jar forming the dielectric or insulating material between the tin foil plates.

30.—If the current in a circuit in which the resistance is constant depends upon the pressure, why should the rule that the current is the same in all parts of an undivided or series circuit hold true when there is a drop in voltage all along the line?

The resistance in the line forms part of the total resistance of the circuit and this resistance from one pole or brush of the generator, through the circuit and back to the other pole or brush of the generator is what limits the current for a given voltage. If this resistance were increased in any part of the circuit, no matter whether in the line or in the apparatus, there would be a corresponding reduction in the current, provided the voltage at the generator was constant. Whatever current is sent out from the positive pole of the generator must necessarily go through all the apparatus in the series circuit and return to the other pole of the generator.

31.—Why does the Edison Mazda incandescent lamp of any given candlepower consume only one-third as much power as an ordinary carbon lamp of the same candlepower?

This is on account of the differently constructed filament in the Mazda incandescent lamp, which glows with a white light instead of the yellow light obtained from the carbon, and requires less current operating on the same voltage to obtain the same amount of illumination. This is a feature which will be brought out later in one of the lessons on incandescent lighting.

32.—What is meant by "The resistance of conductor is inversely proportional to the area of its cross section?"

If the area of the cross section of a conductor is increased and other conditions remain unchanged, the resistance of the conductor will be decreased. For instance, if the area of the cross section is doubled, the resistance is halved; or, if the area of the cross sec-

tion is halved, the resistance is doubled. Then the resistance of a conductor increases with the decreasing area of cross section, and diminishes with the increasing area of cross section, and exactly in the same ratio.

33.—Is the Centigrade scale used very much in electrical work?

The Centigrade scale is used quite extensively in different technical books in which temperature conditions are considered. It would be well to become familiar with the method of changing from Centigrade to Fahrenheit as explained in Lesson No. 1.

34.—Why are the Tungsten lamps so much better than the ordinary carbon lamps? In what ways are they superior?

This will be fully explained in a later lesson on incandescent lamps. On account of the different construction of the filaments the same amount of light, and of a better quality, is obtained from a Tungsten lamp than from a carbon lamp, with a smaller consumption of power. The filament in the Tungsten lamp is more easily broken than the one in the carbon lamp.

35.—After adding three more shunts to the multiple or divided circuit as in Fig. 4, Lesson No. 1, with resistance of 5 ohms each, the total current with the seven shunts on this circuit is 154 amperes. Assuming that the voltage is the same, it does not seem reasonable that, with the addition of resistance, there should be more current flow. Kindly explain this.

The method of adding resistances in multiple, as shown in Fig. 4, obtains the result which should be expected by connecting resistances this way. The more resistances connected in shunt, divided circuit or multiple, the less is the total resistance of the circuit. This should be readily understood from the water analogy, assuming that the pipes are all of the same size, connected through between two reservoirs the same distance apart, that is, under the same head, then the greater the number of pipes so connected the greater would be the water flow or the less the resistance between these two bodies. Similiarly with the electric circuit.

36.—Is not *ohm* pronounced with short "o" as in on?

The word *ohm* is pronounced as "oam" in the word "loam"—long "o."

37.—Electrolysis affects lead covered cables through sections having a difference in potential of but a few volts. Does this mean two lead covered cables carrying current having a difference in voltage, which causes a chemical action, or is it caused by current through the earth from the higher potential line? If both cables carried the same tension current, would there be any electrolysis upon the lead covers?

The difference in potential mentioned does not have reference to potentials of the circuits in which these cables are used, but to the difference in potential between the sheaths of these cables and the earth or zero potential. It is this difference or potential which causes current to flow to or from the cable sheath when it is in contact with the moist earth. The sheath of the cables is insulated from the conductors inside it.

38.—In the charge of a 2 M. F. condenser there would be .000002 Coulombs if one volt was impressed across the terminals, and this would be increased to .000048 coulombs if the voltage were increased to 24. Would this increase the capacity of the condenser to more than 2 M. F., which is all it can hold, or would it charge the condenser quicker?

The rating of capacities of condensers is dependent upon the voltage of the charging current, as well as upon the design of the condenser. The rating of the regular condensers is based upon a charge at a potential of one volt. When this potential is increased, the amount of the electricity which would be supplied to the condenser would be increased accordingly, but the capacities for the higher voltage woudl remain the same. The time element does not enter. Condensers will be more fully discussed in a later lesson.

39.—It states in Lesson No. 3 that connecting cells in series increases the current output, yet with the gravity cells connected in series the current output is limited by the internal resistance to ¼ ampere. This does not seem to be an increase over the current of the individual cell. Does not the increased internal resistance of the cells in series neutralize the increase in current which might be available?

This statement applies up to a certain limit, which would be determined by the design of the cell and the resistance of the external circuit. When the internal resistance of the cells is small compared with that of the external circuit, then this holds true, but would not in case of a short circuit or one of very low resistance which you mention. The resistance of the gravity cell is comparatively high and connecting them in series on a circuit of very low resistance does not increase the current output of the battery to any appreciable extent.

40.—Show the direction of the current flow and the course it is supposed to take when passing through the electrolyte and connections of cells in parallel?

In the figure the cells are all connected in parallel or multiple; that is, all the positive electrodes are connected together and all the negative electrodes are likewise joined, thus in effect making one large cell in which all the zincs constitute the positive element and all the coppers the negative element. Inside the cells, or in the internal circuit, the current is assumed to flow from the positive elements to the negative elements. Outside of the cells, or in the external circuit, the direction of the current is from the copper or positive poles, which form the negative electrodes, to the zinc or negative poles, which form the positive electrodes.

41.—Why does one wire have a larger resistance than another of the same material but of larger diameter?

This may be explained by referring to the comparison of the electric circuit with the water system. More water will flow through a large pipe in a given time under the same pressure than through a small one. This is due to the friction of the water in the pipe, and is greater in small pipes than in large ones. The resistance that a conductor offers to the flow of current corresponds to the friction of the water in the pipe.

42.—What is the difference between one ampere-hour and one watt-hour?

One ampere-hour is the quantity of eelctricity which passes through a conductor during one hour when the current is one ampere. The quantity "ampere-hours" is the product of amperes and hours. Thus two amperes flowing for one-half hour would be one ampere-hour just the same as one-fourth ampere for four hours, etc.

One "watt-hour" is the quantity of electrical energy expended in a circuit when one watt (product of volts and amperes) is furnished for one hour. This is the product of pressure, current and time. The difference between ampere-hours and watt-hours is that the pressure or voltage of the circuit is considered in the latter and not in the former.

43.—Is there more "copper loss" in a bare wire than one covered with insulation, the wires being the same size and length?

Assuming the two wires were of the same material, carrying the same current at the same temperature, then the "copper loss" would be the same in both instances.

44.—Which wire has the greater resistance, the bare wire in air or one covered with insulation of the same size and length?

There is no difference in the resistance if the two wires are of the same material, length and at the same temperature, but the allowable current for insulated wire is less than that for bare wire to prevent the gradual deterioration of the insulating compound caused by the heat due to the resistance of the wire.

45.—Why is it, the greater the resistance, the more heat developed?

For the transmission of a given amount of power, there is a greater line loss when the higher resistance line wire is used, providing the current is kept the same. This means that the voltage at the power house would have to be increased and that the additional losses caused by the higher resistance would be dissipated as heat. This increase in the losses resulting from the increased resistance, R, is represented by the formula $W = I^2R$.

46.—Does increasing the area of the plates increase both the life and voltage of a cell?

Increasing the area of the plates increases the life of the cell and decreases the internal resistance, but does not change the voltage. This means that a cell the size of a teacup would have the same E. M. F. as a cell of the regular size, using the same kind of elements and electrolyte. The voltage of a cell is determined by the kind of elements and electrolyte.

47.—What is the number of K. W. hours required to operate 78 arc lamps connected in series, if they require 6.6 amperes and 70 volts per lamp and are burned for 1,743 hours?

The total power consumption would be the product of the current, pressure and time.
$6.6 \times 70 \times 78 \times 1743 = 62810748$ watt hours, or 62811 K. W. hours.

48.—Do two 8 candlepower 110 volt lamps consume as much power as one 16 candlepower 110-volt lamp, if the filaments are both the same?

If their construction is the same, then the same number of watts per candle-power would be required and they would both consume the same power for the same illumination.

49.—Is the power that returns to a battery or dynamo of any use in sending the current out again?

The circuit must be completed before any power is furnished to the external circuit. That means that a continuous connection must be made back to the battery or dynamo, and in this respect is essential. Aside from this it has no value for producing power, as it is of zero potential when it reaches the generator.

50.—Is a condenser a form of storage or secondary battery?

No, the condenser is not used the same as a storage battery. It is more for the purpose of separating direct and alternating current, as direct current will not pass through it but alternating current will. Their uses in circuits will be more fully explained in later lessons on telephony.

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Fifth Lesson—Primary Batteries.

Ques. No. 78. What is the difference between series multiple and multiple series connection for batteries. If each cell generates a potential of 1 volt, what is the potential delivered to the external circuit, assuming a total of 30 cells connected, 5 in series and 6 in series multiple in each case?

Ans. 78. The series multiple combination is where the batteries are arranged as shown in diagram B, that is, where we have a series connection of 5 sets consisting of 6 cells each in parallel. The multiple series connection is as shown in diagram C, where we have 6 sets connected in parallel, consisting of 5 cells each in series. In each case the voltage at the terminals would be 5 volts.

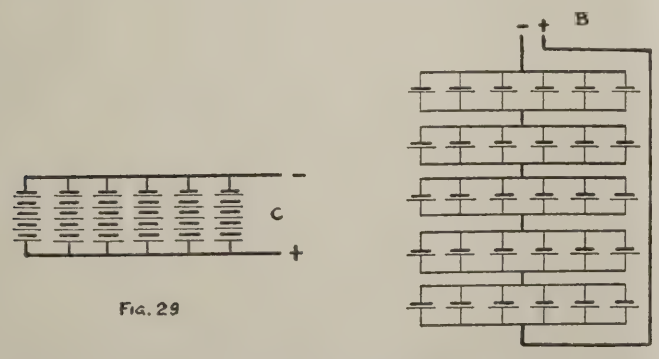


Fig. 29

Fig. 29. Showing the Relation of Series-Multiple (B), and Multiple-Series (C)

Ques. No. 79. If the 30 cells of problem 78 each have a capacity of 250 ampere hours and the external resistance of the circuit is 20 ohms, and the batteries are operated in continuous service, how long will they last if connected in series parallel combination, and how long in the parallel series combination?

Ans. 79. With the terminal voltage of 5 volts as found in problem 78, and with a resistance of 20 ohms in the external circuit, the current flow, neglecting internal resistance of the battery, would be (5 divided by 20 or) .25 of an ampere.

It will be noted from referring to the diagrams, Fig. 29, that there are six paths for this current in passing through the battery in both the series-parallel and the parallel-series combinations. In either case only 1/6 of the total current would pass through any one cell, provided both the cells and connectors are in perfect condition. The current through each cell would then be (.25 divided by 6 or) .042 amperes. This amount of current flowing continuously would consume (24 x .042 or) 1 ampere hour per day. Since the battery is of 250 ampere hours total capacity, it would last 250 days in this service.

It will usually be found that a few of the cells in such a battery are in poor condition or have corroded connectors, etc. This will cause less current to flow through that particular cell and so shift the load over to the other cells. In the series-parallel combination, as shown in Fig. B, a poor connector or a bad cell will shift the load over to the other 5 cells in parallel with it, while

in the parallel-series combination, as shown in Fig. C, a bad connector or a low cell will decrease the current flowing through all of the cells in series with it and shift the entire load, which should be borne by the other 4 cells in that set, over to the remaining 25 cells in the other series circuits. For this reason the series-parallel combination, as shown by Fig. B, is to be preferred in most cases.

First Lesson--Fractions

1. Reduce to a common denomination the fractions 2/15, 5/20 and 1/4.

Ans. 1. The lowest common denominator for these fractions is 3x5x4, or 60, therefore reducing all the fractions to this denominator, 2/15 becomes 8/60; 5/20 becomes 15/60; and 1/4 becomes 15/60, therefore, adding these gives 38/60; this fraction reduced to its lowest terms becomes 19/30.

2. Reduce to the lowest terms the fractions 5/16, 10/20 and 7/21.

Ans. 2. The fraction 5/16 is already in its lowest terms. Dividing both numerator and denominator of 10/20 by 10 this fraction becomes 1/2; by dividing both numerator and denominator of 7/21 by 7, this fraction becomes 1/3.

3. Change to mixed numbers the fractions $\frac{18}{4}$, $\frac{26}{5}$ and 4/3.

Ans. 3. 4 goes in 18 four times and 2 over, therefore 18/4 is 4 2/4 or 4 1/2. 5 goes into 26 five times and one over, therefore 26/5 is 5 1/5. 3 goes into 4 once and 1 over, therefore 4/3 is 1 1/3.

4. Change to improper fractions the mixed numbers 3 1/4, 5 1/3 and 6 1/5.

Ans. 4. 3 is the same as 12/4, therefore the fraction 3 1/4 becomes 13/4. 5 is the same as 15/3, therefore the fraction 5 1/3 becomes 16/3. 6 is the same as 30/5, therefore 6 1/5 becomes 31/5.

5. Add the fractions 1/2, 1/4 and 1/8.

Ans. 5. In adding fractions it is necessary to first reduce all fractions to the same denominator. Therefore, reducing all to a common denominator of 8, 1/2 becomes 4/8; 1/4 becomes 2/8 and it is then possible to add 4/8, 2/8 and 1/8, which gives us 7/8.

6. Add the fractions 1/7 and 1/4.

Ans. 6. It is first necessary to reduce both of these fractions to a common denominator. 28 is the only number common to both 7 and 4, therefore both fractions must be reduced to this denominator; 1/7 then becomes 4/28, and 1/4 becomes 7/28, and the sum of the two fractions is then 11/28.

7. Add the fractions 1/5, 1/6 and 3/9.

Ans. 7. It is first necessary to reduce all fractions to a common denominator as was done in the preceding problems. The smallest number divisible by 5, 6 and 9 is (5x2x3x3 or) 90, therefore 1/5 becomes 18/90; 1/6 becomes 15/90 and 3/9 becomes 30/90, giving a total of 63/90 or 7/10 as the answer.

8. Subtract the following: 6/10 minus 2/5; 4/5 minus 1/3 and 2 1/4 minus 7/8.

Ans. 8. (A) 2/5 is the same as 4/10, therefore 6/10 minus 4/10 gives 2/10, or 1/5. (B) reducing 4/5 and 1/3 to a common denominator, these fractions become 12/15 and 5/15; 12/15 minus 5/15 gives 7/16 or the answer. (C) reducing 2 1/4 to a fraction with a denominator of 8, we get 18/8, this minus 7/8 gives us 11/8 as the answer.

9. Multiply 2/5 x 1/4 x 1/3.

Ans. 9. In multiplying fractions we multiply all the numerators together and all the denominators together, therefore 2x1x1 is 2, and 5x4x3 is 60, the answer is then 2/60 or 1/30.

10. Divide (a) 1/4 by 1/2, (b) divide 4 by 1/3, (c), 3 1/2 by 2/5.

Ans. 10. In dividing fractions we simply invert the divisor and multiply. Therefore, (A) 1/4x1/2 (inverted becomes 2) and gives 2/4 or 1/2 as the answer; (B) to divide 4x1/3 you simply invert the fraction of the divisor (1/3) and multiply, giving 4x3, or 12 as the answer; (C) it is first necessary to reduce the mixed number 3 1/2 to improper fraction, which gives us 7/2. To divide this by 2/5 we simply invert the divisor and multiply (7/2x5/2) or 35/4 as the answer.

Second Lesson--Decimals

9. Write out in words the following: (a) 12.26, (b) 4.015, (c) 17.2423.

Ans. 9. (A) Twelve and twenty-six hundredths; (B) Four and fifteen thousandths; (C) Seventeen and two thousand, four hundred twenty-three, ten thousandths.

10. Add the following: 13.27, 1.329 and 148.435.

Ans. 10. The answer is 163.034.

11. Subtract, (a) 7.48 from 135.27, (b) 4.328 from 7.02.

Ans. 11. (A) 127.79; (B) 2.692.

12. Change the following to a common fraction and add .25, .375, .50 and .125.

Ans. 12. .25 expressed as a fraction becomes 1/4 or 2/8; .375 becomes 3/8; .50 becomes 1/2 or 4/8; .125 becomes 1/8. The sum of 2/8, 3/8, 4/8 and 1/8 is then 10/8 or 1 1/4.

13. Change to decimals: 1/5, ¼, ⅓, ¾, 8/10 and 2/25.

Ans. 13. The above numbers changed to decimals are as follows: .2; .25; .333; .75; .8; .08.

14. Multiply: (a) 7.4325 × 2.27, (b) 75.387 × 2.52.

Ans. 14. (A) 16.871775; (B) 189.97524.

15. Divide: (a) 3.25 × .25, (b) .38 × 2.27, (c) 1.045 × 3.75.

Ans. 15. (A) 13; (B) 0.1674; (C) 0.2786.

Third Lesson--Ratio and Proportion

16. What is the difference between arithmatic and geometric ratio?

Ans. 16. Arithmetical ratio is where the arithmetical difference between the number in a series is a certain number, such as 3, 6, 9, 12, or 4, 8, 12, 16, etc.

Geometrical ratio is where each number in a series is a certain multiple of the one preceding, and all numbers of the series differ from each other by this same multiple. For instance, 2, 4, 8, 16 (multiple is 2), or 3, 6, 12, 24 (multiple is 2).

17. What is meant by inverse ratio and direct ratio?

Ans. 17. Direct ratio is used to express the relation between two quantities or numbers in terms of other numbers, for instance, the ratio of 16 qts. to 8 qts. is as 2 to 1.

Inverse ratio might be considered as just the opposite of direct ratio, for instance, we speak of the field current of a car lighting generator varying inversely with the train speed; this means that as the train speed goes up, the field current goes down. Another example of inverse ratio is that the resistance of a wire varies inversely with the cross section, the larger the cross section, the lower the resistance.

18. If the resistance of two similar conductors varies inversely as the square of their diameters, how does the resistance of a rod 300 mills in diameter compare with 150 mills in diameter?

Ans. 18. The rod of 300 mils diameter is twice the diameter of the 150 mil rod, or the ratio of diameters is 2 as to 1. Since the resistance varies inversely as the square of diameters, the relative resistance of the large rod to the small will be as 1/2 squared is to 1/1 squared, or in other words, as 1/4 is to 1. The resistance of the large rod will then be 1/4 as great as that of the small rod for an equal length.

19. If 25 men can do a certain piece of work in 45 days, how long will it take to do the work if 10 extra men are added, assuming that the new men work with the same speed as the original 25.

Ans. 19. The length of time required to do the work will vary inversely with the number of men employed. Therefore, if 35 men are employed instead of 25, it will take only 25/35 of 45 days to do the work, or about 32 1/4 days.

Fourth Lesson--Evolution

20.—Raise the following numbers to the powers given: (*a*) 2^2, (*b*) 5^2, (*c*) 12^2, (*d*) 4^3, (*e*) 8^3, (*f*) 5^5, (*g*) $(3\frac{1}{2})^2$, (*h*) $(5\frac{1}{2})^2$, (*i*) $(8\frac{1}{3})^2$.

Ans. 20. (A) 4; (B) 25; (C) 144; (D) 64; (E) 512; (F) 3125; (G) 12 1/4; (H) 30 1/4; (I) 69 4/9.

21.—Find the square root of the following: (*a*) 169, (*b*) 400, (*c*) 132, (*d*) 3, (*e*) 1.025, (*f*) 16.01.

Ans. 21. (A) 13; (B) 20; (C) 11.489; (D) 1.732; (E) 1.0124; (F) 4.001.

23.—How many litres in a tank in the shape of a cube 3 ft. on a side?

Ans. 23. A tank in the shape of a cube 3 ft. on the side would have a volume of 3x3x3, or 27 cubic feet. Since there are 7.48 gallons to a cubic foot, there will be 27x7.48 or, 202 gallons in this tank. Since 1 gallon is the equivalent of 3.79 litres, there will be a total of 764 litres in this tank.

24.—A walk is made of boards 6 in. wide, 1¼ in. thick, and the boards are laid crosswise with ½-in. space between them. The walk is 3 ft. wide, but the boards are 10 ft. long, causing a waste of 1 ft. on each board. If the walk is 500 ft. long and the boards cost $25.00 per M. ft., how many board ft. should be ordered and what will it cost?

Ans. 24. Since the walk is 500 ft. long, and each board 6 in. wide with a 1/2 in. space between, it will then be 6 1/2 in. from the center of one board to the center of the next. 500 ft. reduced to inches (500x12) 6,000 in., the number of boards in the walk is 6,000 divided by 6 1/2 or, 923 boards, 3 ft. long. It will be possible to cut 3 of these boards from each 10 ft. length of lumber as received, therefore, the total number of 10 ft. pieces is (923 divided by 3 or) 308, giving a total lineal feet of lumber ordered of 3,080 ft. This is, however, only 6 in. wide, but is 1 1/4 in. thick, and since board measure is always figured 12 in. wide 1 in. thick, the amount of lumber in these 308 pieces is $\frac{3{,}080 \times 6}{12} \times 1\ 1/4$ or) 1,925 board feet. This at $25.00 per thousand would cost (25x1.925 or) $48.15.

Fifth Lesson--Miscellaneous

25.—Assuming that chestnut poles weigh 55 lbs. per cubic ft., what will be the weight of a pole 40 ft. long having top diameter of 8 in., butt diameter 13½ in.?

Ans. 25. The area at the top will be 8x8x3.14x1/4 or, 50 1/4 square inches, while that at the bottom will be 13 1/2x13 1/2x3.14x1/4 or, 143 square inches. Adding these areas and dividing by 2, we get 96 3/4 square inches as the average sectional area of the pole. (This is not a mathematically correct way of getting the volume, but is accurate enough for practical purposes here.)

Since there are 144 square inches in a square foot, this average section will contain (96 3/4 divided by 144 or) .67 square feet. This average section times the length of the pole, (.67x40 ft. gives us 26.8 cubic feet as the volume of the pole. Since chestnut weighs 55 lbs. per cubic ft. the weight of the pole will be 26.8x55 or, 1,474 lbs.

26.—What should be the length of each of the rods to form a hoop for a circular water-tank at a point where the outside diameter is 12.4 ft., if the rods should lap 4 in. to make a good joint and there are 4 joints in the hoop?

Ans. '26. The circumference of a tank 12.4 ft. in diameter is (12.4x314 or) 38.9 ft. If the rods lap 4 in. at each joint, and there are 4 joints, the total length consumed in lap will be 16 in. or 1.33 ft. This added to the circumference, gives a total of 40.2 ft. for the total length of the rod.

27.—If this is the lower hoop and comes over the joint for the bottom, and the thickness of the boards in the side is 2 in., what is the inside area of the bottom?

Ans. 27. Since the boards of the sides have a thickness of 2 in., the inside diameter of the tank would be 12 ft. times the area, this is then (12x12x3.14 divided by 4 or) 103 sq. ft.

28.—What is the area of a square platform the side of which will just come flush with the outside of this tank?

Ans. 28. A square platform 12.4 ft. on the side would have an area of (12.4x12.4 or) 153.6 sq. ft.

29.—If this tank had been square and held the same number of gallons, (*a*) what would be the inside circumference, assuming that the height is the same as the circular tank? (*b*) Outside circumference or perimeter?

Ans. 29. (A) Since the square tank is to have the same gallon capacity, and the same height, it must have the same number of sq. ft. area at the bottom. This, as found in problem 27, is 103 sq. ft. To find the length of one side of the square, we simply take the square root of this number, which gives us 10.14 ft. The inside circumference would then be (4x10.14 or) 40.6 ft. (B) Since the planks of the tank are 2 in. thick, the outside dimensions of this square tank will be 10.3 ft., therefore, the outside circumference will be (4x10.3 or) 41.2 ft.

Problems for Next Month

First Lesson.

1.—Give two methods of magnetizing a piece of steel.

2.—A steel ball is plated with copper and enclosed in a wooden box. Will it be attracted by a magnet brought near it?

3.—If you were given a compass, how could you determine the north and south poles of a generator?

4.—Two bar bagnets are laid side by side with their N poles adjoining.
   (*a*) Would they attract or repel each other?
   (*b*) Make a sketch showing the distribution of the magnetic field about these magnets.

5.—One of the magnets in question 4 is turned around, end for end.
   (*a*) What difference does this make in the force between the two magnets?
   (*b*) Make a sketch showing the distribution of the magnetic field.

6.—The magnetic pole at the left side of Figure 6 (Jan., 1914, Lesson) is a north pole. Make a sketch showing the location and sign (whether positive or negative, north or south) of all other poles in the figure.

7.—If a magnetic compass were placed between the poles of a horseshoe magnet, how would the compass needle behave?

8.—(*a*) What shape should a magnet have to best retain its magnetism?

(*b*) How can two straight bar magnets be arranged together so that they will not lose their magnetism?

9.—Why does a compass needle take up a definite position on its pivot? Explain fully.

A. B. C. Car Lighting Course

Edited by Edward Wray

The first lesson of this course was published in our Feb., 1912, *issue. All back numbers covering over two years' work can be furnished, bound in heavy paper covers with special binding arrangement, so that future lessons can be added and preserved. This also includes all back lessons of the P. R. R. School of Electricity, the R. R. Electricians' Club, Prize Question Box, and Practical Stunts. Price* $1.00. (*See blank on page* 6.)

Lesson No. 27

Leitner Train Lighting System

The "Leitner" system, formerly known as the "Leitner-Lucas" system, has been extensively employed for railway car lighting in England and Continental countries. This equipment was described to a certain extent in our February, 1912, issue in connection with a paper on the "Brake Vehicle System of Train Lighting," in which 3 or 4 cars on the train are lighted from one axle dynamo.

The Leitner equipment is radically different in many respects from any other axle lighting system, and we feel sure that a detailed description of the equipment and its operation will interest the car lighting men studying this course.

Generator.

In order to control the generator voltage and output as the train speed rises, the field current of the generator must be correspondingly reduced. This is accomplished in the Leitner dynamo by inserting a pair of auxiliary brushes D and D-1, Fig. 143, which are placed midway between the main brushes of the dynamo. In practice a four pole machine is employed, but for the sake of simplicity in explanation a two pole machine is shown in the diagram.

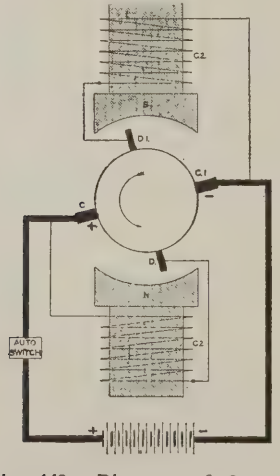


Fig. 143. Diagram of Generator Circuit Showing Field Control by Armature Reactions.

It will be noted that the field current of the generator after leaving the positive pole and passing through one field winding, again passes through the armature from the brush D to D-1, thence through the other coil to generator negative. On starting, a weak magnetic field generated by exciting coils will be uniformly distributed over each pole face and since D and D-1 are given a slight lead, there will be a voltage developed across D to D-1 with D-1 as positive. This voltage will assist the main voltage of the generator in building up the field current on starting. An auxiliary coil is placed on each generator field, which acts as an exciter to assist the generator to build up quickly and always in the right direction. This is connected directly to the battery and is cut out of service when the last lamp circuit is opened.

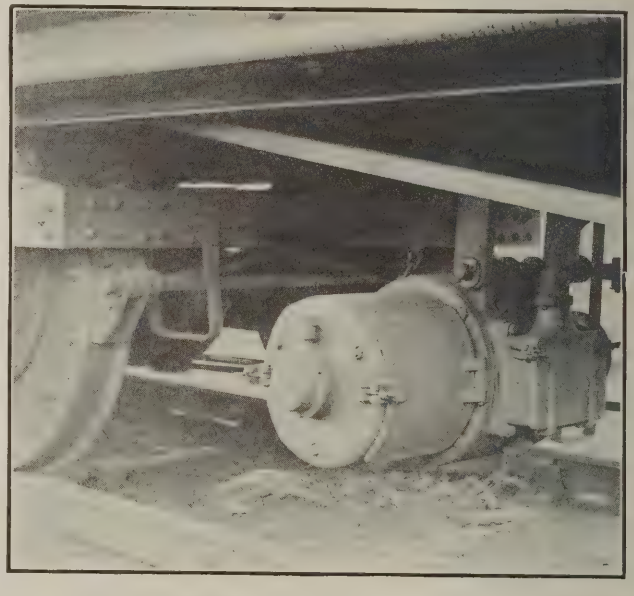


Fig. 144. Leitner Generator. Note the Pendulum Link Suspension.

When the automatic switch closes there will be a fairly heavy current flow through the armature to battery or lamps, and this current flowing through the armature coils will produce armature re-actions, or cross magnetism in the armature, which will distort the main field of the generator and cause it to shift in the direction of rotation through an angle of 20 to 30 degrees.

All four brushes are given a slight lead, that is, revolved through about 10 degrees in the direction

through which the armature rotates, and it is this fact which causes the auxiliary brushes to give a voltage which assists the field current when it first builds up. When the automatic switch closes, however, the armature re-actions, as above explained, gradually shift the main field, which causes the voltage developed in the auxiliary brushes to be first reduced to zero (which is the condition when the shift of the field, due to the armature re-actions is just equal to the lead given the brushes), and as the speed and load further increases the armature re-actions shift the generator field still farther and the auxiliary brushes D, D-1, then give a counter electro motive force which opposes the flow of field current, and by so reducing the field current, compensates for the rise in train speed.

Fig. 145. English Coach Showing Location of Battery and Generator.

Fig. 145. English Coach Showing Location of Battery and Generator.

An adjustable resistance with 4 contact points is mounted on the dynamo so that the output can be adjusted as desired. This resistance is placed in series with the generator field current.

The "lead," which is given the brushes, mentioned above, is limited by an adjustable stop, and as the brushes are free to revolve through the angle of lead, in either direction, the friction of the armature on the brushes will carry the brush rig along on the reversal of direction of rotation. The required angle of "lead" is then always maintained in the right direction and is independent of direction of rotation. The output of the generator can also be adjusted by adjusting the angle of "lead" given the brushes. Increasing this angle of "lead" will decrease the counter electro motive force in the field circuit and increase the output. Characteristic curves showing the operation of the dynamo are given in Fig. 146. It will be noticed that at 30 mi. per hr. the generator output is a maximum and at higher speeds the output is reduced.

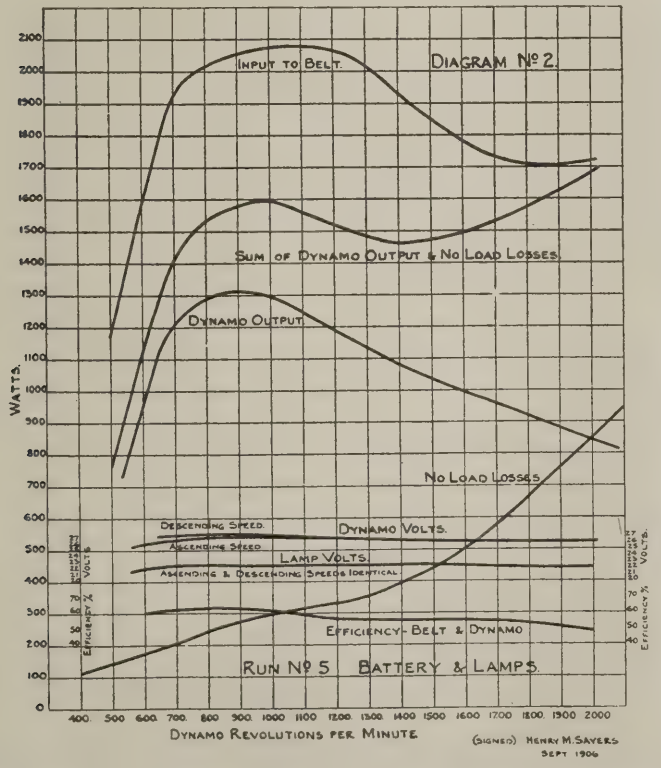


Fig. 146. Curves Showing Variation of Dynamo Output with Speed.

Auto Switch.

The automatic switch of this equipment is entirely different from any previously described in this course of lesson, but like the E. S. B. equipment described in our Nov., 1913, issue, it operates when the generator voltage rises 1 or 2 volts higher than that of the battery, instead of operating at a certain voltage as most auto-switches do.

It consists essentially of a spring controlled pivoted armature C, upon which is wound many turns of fine wire, and this coil connected to the battery circuit, as shown in the diagram. This creates a north and south pole in the armature with a horizontal axis, as shown in the diagram. This movable armature carries the contact arm F, which is normally held in the

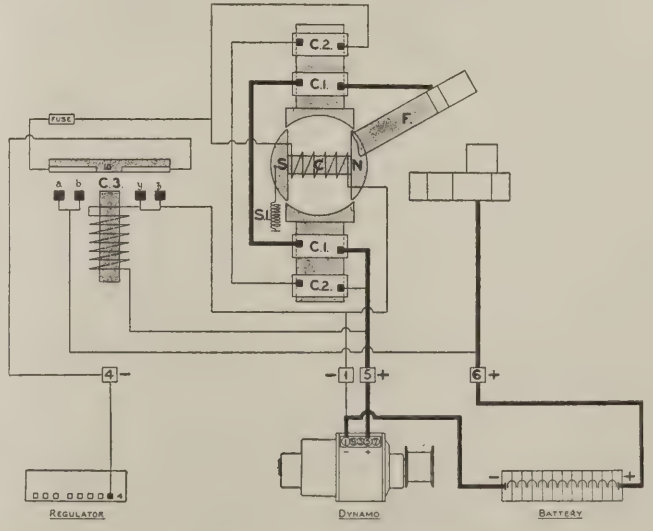


Fig. 147. Wiring Diagram of Automatic Switch.

raised position by the spring S-1. On a vertical axis are placed the coils C-1 and C-2, C-1 coils being composed of a few turns of heavy wire placed in series with the generator circuit, and C-2 coils composed of a large number of turns of fine wire connected between generator positive and battery positive.

The auxiliary switch C-3, shown at the left of the diagram, Fig. 147, is designed so as to close when the generator voltage gets up to 15 volts (the system is

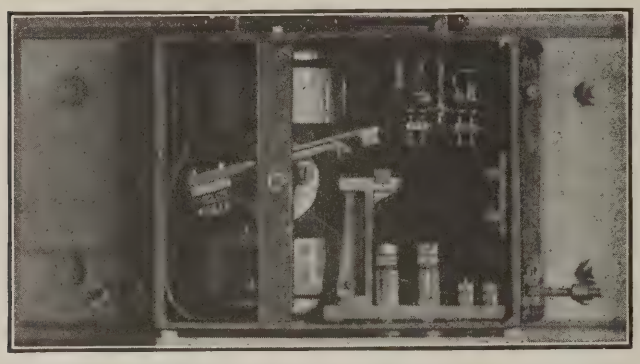


Fig. 148. Automatic Switch.

operated at 24 volts). Before this switch closes and draws the armature w down across the contacts a, b, y and z, there will be no current flowing through either the armature coil of the switch, or the stationary coils C-2. As soon as C-3 closes, however, full battery voltage is placed across the coils C and current will flow from the battery positive through the coils C-2 to the generator positive (via contacts ab of relay C-3), through the armature winding to battery negative. The direction of flow of current through coil C-2, creates magnetism in such a direction that the armature tends to revolve in a direction to raise the contact arm F.

When the generator voltage gradually rises so that it is just equal to the battery voltage, this current will gradually flow to zero; but as the generator voltage rises above that of the battery, current will then flow through the coils C-2 from dynamo positive to battery positive, this being in the reverse direction from what it was originally. A generator voltage of a few volts above the battery will cause sufficient current to flow through the coils C-2, and since this creates magnetism in the opposite direction from formerly, it will cause the armature of the auto switch to revolve in a clockwise direction, overcoming the pull of the spring S-1 and drawing down the contact arm F.

As soon as this switch closes it automatically short circuits the coils C-2, but this allows the generator current to flow through the series coil C-1 to the battery and lamps and the magnetism of the series current holds the switch firmly closed.

On decrease in speed below cutting in speed the generator current will gradually fall to zero, and as soon as this occurs, the spring S will lift the switch arm F since there is no magnetic flux in either the coil C-1 or C-2 to hold it down at that time. When the generator voltage falls below 15 volts, the relay C-3 drops open and prevents full battery voltage coming back on the coils C-2.

The Regulator.

The regulator of this equipment may be divided into three principal parts:

1. Voltage balance.
2. Small motor controlled by double relay.
3. Triple scale rheostat.

The diagrams shown in this connection have been divided so as to show the detail of the motor and relay circuit and automatic switch separate from the main regulator circuit, for the sake of simplicity.

Voltage Balance and Single Relay.

The voltage balance consists of a solenoid M, Fig. 151, core of which is attached to a pivoted arm having contacts at each end Q. If the magnetic pull on the plunger is stronger than the pull of the adjustable spring, contact will be made at Q, or vice versa at Q-1; but if the magnetic pull on the plunger M is just equal to the pull of the spring, the device will be in balance and neither contact will be closed. The contacts Q and Q-1 control the coils of a double relay, which, in turn, governs the operating motor, causing it to move the resistance arm W to the right or left on the triple scale rheostat as desired.

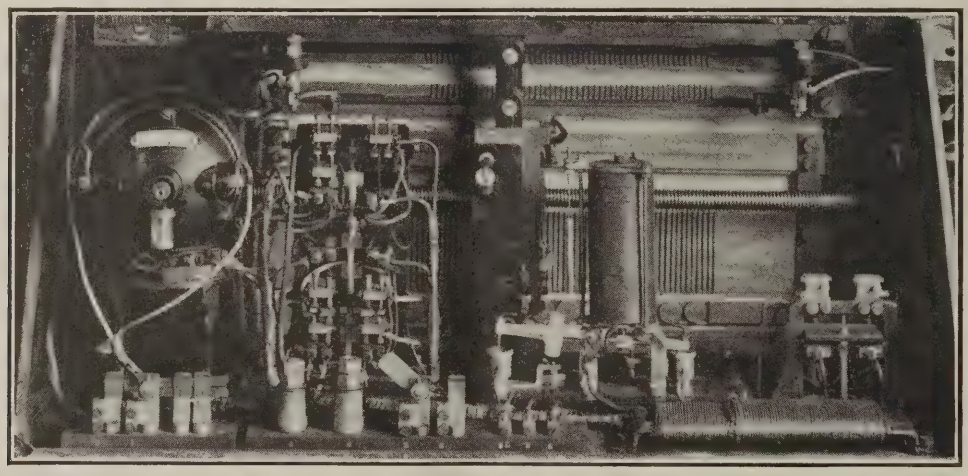


Fig. 149. Regulating Apparatus. Note Operating Motor and Triple Row of Resistance Contacts.

Operation of the Regulator, Day Conditions.

In day operation, with no lights on, the solenoid M is energized by battery voltage, contact being made through the relay C-3, Fig. 147, after the generator voltage rises above 15 volts. The solenoid is thus energized from the battery positive No. 6, through contact arm W on the rheostat, through the progressive resistance to N, or contact N-1, as the case may be, thence through the solenoid M to the battery negative.

Assuming that M is energized and that the pivoted solenoid arm is in equilibrium, any rise of voltage will increase the pull of the solenoid M, this will overcome

the pull of the spring and make contact at Q, which will cause the motor to move the contact W along the resistance segment away from N. The resistance in series with the solenoid will thus be increased, causing the pull of the solenoid to be decreased until

Fig. 150. Note the Train Connectors are Located Just Above the Floor Line, One on Each Side of the Vestibule.

equilibrium is again restored and the contact Q opened.

On the other hand, if the voltage falls, the spring will overcome the magnetic pull of the solenoid, making contact at Q-1, which will cause the motor to move

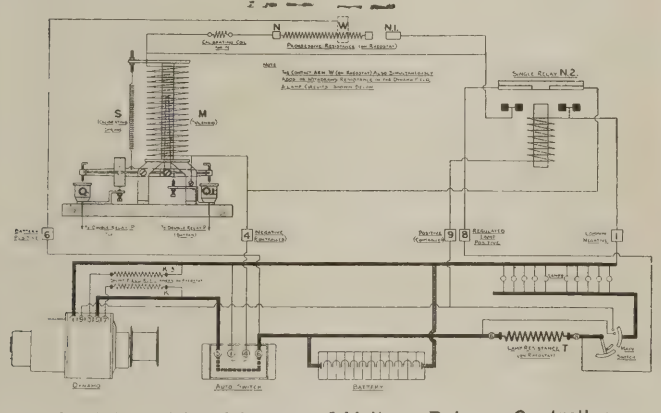


Fig. 151. Wiring Diagram of Voltage Balance Controller.

the arm W toward N, thereby decreasing the resistance and increasing the pull of the solenoid until equilibrium is again restored.

Assuming, however, that the voltage be steadily rising as the battery continues on charge, the arm W will move away step by step from N and insert more and more resistance, not only in the solenoid circuit, shown at the top of the diagram, Fig. 151, but also in the dynamo shunt field through K and K-3, thereby reducing the output of the dynamo and the charging current given the battery toward the end of charge.

At a predetermined voltage, which corresponds to maximum voltage on charge (3 volts per cell), the contact W has been moved over so that it makes contact at N-1. This cuts out all the resistance N and thereby increases the current through the solenoid M, which causes the motor to move the contact W to the extreme right. At this point, W automatically opens the motor circuit so that further movement in that direction is impossible. The dynamo field, with all the resistance K and K-3 in circuit, is so weak that its output is reduced almost to zero.

This equipment, like all other voltage regulators, assumes that the battery is fully charged when it reaches a certain voltage. From the previous lessons we have seen the fallacy of this reasoning, but since the equipment is designed to operate on a tapered charge principle instead of a stop charge, it may operate satisfactorily in this service providing the maximum voltage at the end of charge is not set too high. Our experience in this country would lead us to consider that the 3 volts per cell limit selected by the manufacturers of this equipment would tend to give overcharging conditions, but this is a matter of detail which can easily be adjusted in the design of the resistance N and field resistance K, so as to establish 2.5 or 2.6 volts per cell as the allowable limit.

Operation of Regulator with Lamps On.

As soon as lamps are switched on a contact is made at the main switch, which closes circuit through the single relay N-2. This short circuits the progressive resistance N and places the solenoid M directly across the lamp circuit. The equilibrium of the balanced arm will now only be disturbed by a variation in lamp voltage from that for which the spring S is adjusted.

If the voltage rises above normal it will increase the pull of the solenoid and make contact at Q until the contact arm W, which makes contact with the resistances N, K and T will move to the right, inserting the resistance in the lamp circuit until the voltage across the lamps has been brought to normal value, at which time the voltage balance will again be in equilibrium and both contacts be open. Any movement of the arm W necessary to insert the required amount of lamp resistance will also insert resistance K and K-3 in the shunt field of the dynamo, and vice versa, thereby reducing the output and voltage of the dynamo, in case the storage battery tends to come to a full state of charge and voltage tends to rise accordingly when any of the lamps are on.

Operating Motor and Control Relay.

The double pole and relay, shown in Fig. 152, is controlled by the contacts Q and Q-1 of the voltage bal-

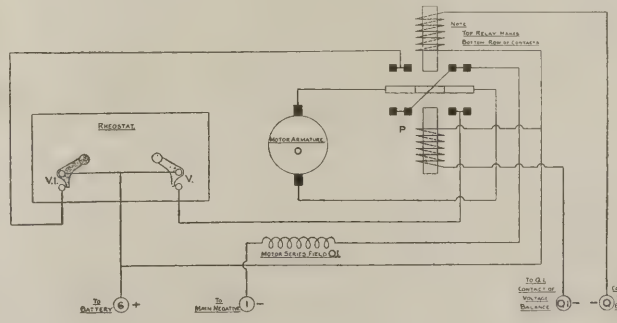


Fig. 152. Wiring Diagram of Operating Motor Circuit.

ance. When the balance is in equilibrium the armature of the relay stands at the neutral position, as shown in the diagram, but when contact is made at Q or Q-1, the armature is drawn up or down, driving the motor armature in one direction or the other, as required to move the contact arm W.

The rotation of the armature is transmitted by means of a skew gear, driving a long screw, which in turn drives a nut on the contact W. The release contacts V and V-1 are provided at either limit.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize .....$1.00 *in cash*
Second prize .....9 *months' subscription*
Third prize .....6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Questions Before the House

Field Fuse Trouble.

No. 3. On Bliss equipments I find that the shunt fuse will almost invariably blow if the automatic switch does not close or if there is an open in the battery circuit. But on the Moskowitz type of equipment I quite often find that the automatic switch does not close and yet the shunt fuse does not blow as it would in a Bliss equipment. Will you try to furnish an explanation?—S. W. Everett, Santa Fe.

Current in Moskowitz System.

No. 4. Why does the current run up on a Moskowitz equipment as the speed of the train increases? That is, if the dynamo is set for 30 amperes when the train is running at 30 miles an hour and when the speed of the train increases to 50 miles per hour, you will find that the output of the machine has raised almost double, to perhaps 45 or 50 amperes.—A. E. Voigt.—Santa Fe.

Water for Flushing Batteries.

No. 6. Why do battery manufacturing companies prescribe that only absolutely pure distilled water must be used for flushing the cells, when if pressed they will all admit that it is permissible to use Lake Michigan water? Is this water of equal purity with distilled water?—J. L. Ohmans, Elec. Fore., C. & W. I. Ry.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Belt Fasteners.

Can any reader advise if he has tried out the Walker belt fastener in cold weather?

In Canada we have tried out the Crescent and Alligator fasteners without success, the belt cracking after about 3,000 miles, due to being stiff through freezing. We are now altering our truck suspensions to permit using the Walker fasteners on all cars, this type of fastener requiring more clearance than the Crescent. E. S. Mac Nab, Can. Pac. Ry.

First Prize

Care of Ball Bearings.

Since the grease gun has not been found satisfactory for car lighting generators, on account of the fact that it is able to force grease out of the housing into the generator case itself, it has become the practice on some roads to grease the machines only at intervals of six or eight months, at which time the heads are opened, bearings taken out and cleaned and regreased. There seems to be more or less diversity of opinion as to the best method to be followed, whether to shop the generator and give them a complete overhauling, or to simply remove the heads and regrease the bearings without removing same from the car.

It would be interesting to hear the comments of different car lighting men on this subject.—L. S. Billau.

To the Editor:

It having been found that one greasing of the ball bearings on axle generators is sufficient to properly lubricate the bearings for a six months' period, it appears to us to be preferable to remove the generator from the car when due for greasing for the following reasons:

During the six months' period the car on which the generator is mounted has traveled fifty to sixty thousand miles and it surely deserves a thorough inspection and overhauling. The electrical equipment, which in service most nearly approximates the axle generator, is the motor of an urban or interurban electric railway which, on well organized roads, is given a thorough inspection on a mileage or time basis. This inspection, which is on a thousand or twelve hundred mile basis, or at approximately weekly intervals, is made over a pit in the inspection shed, and the car is not allowed to depart until each item has been tested and inspected. The entire equipment, motor as well as control apparatus, is much more rigid and substantial than is the generator and its regulating apparatus, nor is a comparatively high voltage motor as susceptible to trouble as a low voltage generator. In view, therefore, of the fact that experience has shown that inspection on approximately the above basis is necessary to insure reliable service of motor equipment, it does not appear excessive to require the same inspection from 1-25th to 1-50th as often on more delicate axle generator equipment.

Granting, therefore, that the inspection of the entire equipment is necessary, it is only reasonable to believe that the inspection can be done to better advantage in the shop than in the yard.

Performing the inspection in the yard is open to the following objections:

a. Loss of efficiency of workmen due to weather conditions.

b. Loss of efficiency of workmen due to not having all necessary tools and supplies at hand, necessitating time lost while the tool or material required is obtained.

c. Liability of loss of small parts on account of same falling in ballast.

d. Much greater liability of parts that have been cleaned again getting dirty and being replaced in this condition.

e. By having reserve equipment as much time as necessary may be taken to make the inspection in a thorough manner instead of having to keep in mind the departure time of car.

As against these objections to doing the work in the yard, we have as an objection to doing the work in the shop, the removing and reapplication of the generator. A little ingenuity will, however, result in minimizing this objection.

It is, of course, possible that yard conditions may be such that the removal of the generator is not feasible, in which case the inspection must be made with the generator in place.

Our experience has shown us, however, that it is preferable to remove the generator if possible.

J. R. Sloan, Engr. Elec. Car Ltg., Penn. R. R.

Ball Bearing Maintenance.

To the Editor:

I think Mr. Billan's suggestion that car lighting men comment on Care of Ball Bearings is a good one, and every one with any experience with ball bearings should write it up so that all may make progress.

On the Santa Fe we assumed that a ball bearing properly greased would run six months without attention. To insure the bearing being inspected at the end of six months, each dynamo has a metal tag about the size of a nickel tied on it. This tag bears a date six months ahead of the date it is applied. The inspector applying the tag reports to the electrical engineer's office the number of car and date it is greased. Inspectors in looking over a dynamo will note whether bearings need grease by date on tag. The date is month only. All tags applied during March will have the number 9. This indicates that the bearing should be greased in September.

Every inspector at terminals is responsible for the greasing of the bearing after Sept. 1st. At present we favor opening the bearing and applying the grease with a paddle, as we do not yet know enough about the life of ball bearings. Yours truly,

S. W. Everett, Elec. Engr., Santa Fe.

Second Prize

Ball Bearings.

Why was a ball bearing large enough for a 16-ton automobile truck adopted as a standard ball bearing for axle dynamos?—Frank Rupple.

To the Editor:

In the early days when this company was attempting to popularize ball bearings for axle generator work, various recommendations of bearing sizes were made to the different manufacturers, depending on their current output, armature shaft diameter, as well as on the weight of the armature and the width of belt which they were using. The smallest bearing sizes which, to our knowledge, have been used in this work, are the No. 306 and No. 309 on the commutator and pulley ends respectively. These were selected without our recommendations and we believe them entirely too small for generator work. We initially recommended to one manufacturer No. 407 and No. 409, the No. 409 being about the size of his armature shaft; to other manufacturers we recommended No. 408 and No. 410; still another manufacturer—and one of the first to experiment with ball bearings—had of his own volition chosen No. 411 bearing, using the same size on both ends. In addition to Hess-Brights he had made experiments with other makes of bearings.

When the first meeting to consider the establishment of a ball bearing standard was convened, there was a wide difference of opinion as to the right size of bearing, each manufacturer holding out for the size with which he had experimented. The ball bearing manufacturers of whom only one, beside the writer was represented taking a neutral stand, since we believe that any of the sizes under consideration were large enough to do the work. The consensus of opinion was that, in order to be absolutely safe on the bearing itself and to get a shaft which was stiff enough, (bearing in mind that the ball bearing having only a short length a somewhat stiffer shaft is necessary than with a plain bearing) the No. 411 size had better be used on the pulley end. The difference in the cost of a No. 411 and a No. 410 was only a very small amount; the railroads represented insisted on having the same bearing on both commutator and pulley ends in order that they could carry one bearing only in stock. After the meeting had been dismissed one of the axle generator manufacturers, who had been doing a great deal of experimenting, made it known to one of the railroad representatives that he had even had some trouble with No. 411 bearings, and that he, for one, would put out nothing but No. 412 bearing regardless of what the consensus of the committee's opinion was. This complicated the situation, and the final result was that everybody agreed to the No. 412 size.

While as you correctly state the rating of a Hess-Bright bearing is 4400 lbs. at 200 RPM, in the No. 412 size, this rate falls off rather sharply with considerable increase in speed, or in shock conditions. It is necessary to put on a bearing which will just as satisfactorily behave at 2000 RPM as at 200. That the shock conditions are very severe is proven by the extremely large sizes which have been found necessary on plain bearings for these machines. We cannot put in terms of pounds what it means to an axle generator bearing to carry loads which will break belts, pull suspensions to pieces, etc. We do know that conditions are severe, and we do not believe that the extra cost of a No. 412 bearing over a No. 410 is unreasonable to the railroad, in view of the extra service which they will undoubtedly get therefrom.

Third Prize

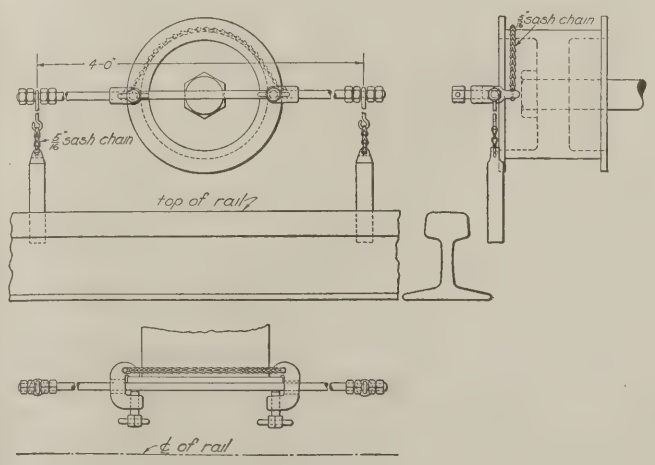
Axle Generator Alignment.

I should like to obtain some information through the Question Box covering quick and easy methods of checking the alignment of axle generators with reference to car axles and which are suitable for use in checking up cars in service and undergoing periodic inspection.

Methods I have seen involve measurements beween axle equipment and the rail or the car axle itself, both of which are apt to result in error if the axis of the axle is not at right angles to the rail or in case the axle is not at right angles to the pedestals due to lost motion in journal boxes, etc.—L. S. Billau, Elec. Dept., B. & O. R. R.

To the Editor:

I send you herewith a print showing a device we have in use for aligning axle generators. The chain is placed



Diagrams Showing Device for Aligning Car Lighting Generator.

over the armature pulley and the bar set approximately level, and the bar is then locked by means of the clamps against the outer flange of the pulley. The generator is then shifted until the distance from each weight at the ends of the bar to the rail is the same. When this po-

sition is obtained the generator suspension is locked and the generator is lined.

J. R. Sloan, Engr. Elec. Car Lighting, Penn. R. R.

Alignment of Car Lighting Generators.

To the Editor:

In case the equipment is being applied to a car, a good way to locate the dynamo is the thresherman's idea of looking across the end of the pulleys. Where the faces of the axle pulley and dynamo pulley are the same, there are four points to have come in line. This will also indicate whether the dynamo shaft and car axle are parallel. It is a quick, easy and sure method of getting pulleys in line. Where the axle pulley and dynamo pulley are not the same width, allowance must be made for the difference in width. Where an equipment has been in service, the wear of the belt on the pulley will show whether the pulleys are properly aligned.

S. W. Everett, Elec. Engr., Santa Fe.

Generator Alignment.

To the Editor:

The method we use in such cases, is to first see that the tension is on the belt, place a square on the end sill and see that both faces of the flange on the armature pulley touches the square evenly—if not, the generator should be moved backward or forward until this condtion is achieved.

Also see that armature pulley has 5/16 in. crown and see that this crown is maintained. When a pulley is crowned 5/16 in., there will be about 14 months' service before the crown is worn necessitating recrowning. If this method is followed, and the pulley watched for the wear of the crown, there should be no belt trouble and the slight variation of the axle being out of square with the pedestals will cause no difficulty.

On the Chicago Great Western R. R., all armature pulleys are recrowned once a year and we have had as high as 16 months' belt life and a general average of between 7 and 8 months. In case of four-wheel trucks having no end sill, a straight edge laid across both ends of the truck will answer the purpose. This may sound too simple, but it is the one simple rule that works.

Geo. R. Shirk, Ch. Elec., Chicago Great Western.

Brake Beam Position.

Should the truck and generator suspension be designed so as to make the lower run of the car lighting belt pass under the brake beam or over it?—Edward Wray.

To the Editor:

My experience in car lighting generator maintenance leads me to favor the location of the brake beam above the belt rather than below it, for the following reasons:

With a 21 in. axle pulley or 10½ in. axle pulley the belt slopes toward the axle and with the belt passing over the brake beam when brakes are applied. Especially with a car wheel badly worn or a worn brake shoe, the brake beam will be drawn very close to the belt, in fact, may come so close that the belt rubs on the brake beam or at least strikes it in flopping with the car motion. This will soon batter the clamp and rivets so that the rivets come loose and the belt is lost.

Where the belt passes under the brake beam, setting the brakes when going in the reverse direction will, of course, draw the brake beam down somewhat and brings it close to the belt. But as the inner face of the belt is entirely smooth there is nothing to strike on the brake beam and this will not injure the belt.—F. H. Hopkins, Elect., Ill. Cent. R. R.

Dead Cell in Battery.

Question. On testing a car which showed low voltage recently, I found that one cell would not give any reading at all, so I disconnected this tray from the rest of the battery and removed both cells of the tray. After getting these two cells out on a truck I tested them again and found that each of the cells gave 2 volts. I can't understand what should cause this particular cell to give no voltage when connected with other cells of the battery and yet give 2 volts when disconnected.—Battery Man, Sunnyside Yards, Penn. R. R.

Answer. This illustrates a very important principle in storage battery operation, which is that the open circuit voltage of the storage battery means absolutely nothing. Even a battery completely discharged and which, when placed on discharge would show almost no voltage, may show a normal voltage on open circuit. In order to tell anything about the condition of a battery from voltage readings the battery must be placed on discharge for at least 2 or 3 minutes before taking a reading. This will give any low cells a chance to fall off in voltage, which will show up their bad condition. This particular cell you refer to was probably discharged locally, due to internal short circuit or impurities in the electrolyte, and when placed on discharge with the other cells of the battery soon lost all of its remaining capacity; the discharge current from the other cells, however, continuing to flow through this particular cell soon pulled its voltage down to zero, and if you had continued the discharge a little longer you would have found that this particular cell had its polarity reversed, that is, the positive pole had become negative and vice versa.

Testing for Low Cells.

Question. When a car comes in with an abnormally low voltage, when is the best time to test for dead cells—before the car is placed on charge or after the charge is completed?—Battery Man, Sunnyside Yards, Penn. R. R.

Answer. Always test for dead cells when the battery voltage is lowest, that is, when the car is first received. If you try to locate the dead cells after the battery had been fully charged, you will probably find that every cell of the battery shows top voltage unless there is a severe short circuit in one or more cells.

Furthermore, be sure that the battery has been on discharge for at least 3 minutes before attempting to locate the dead cells, for open circuit voltage or voltage as soon as discharge current is first taken from the battery will probably show high on all cells, even the dead ones.

It is necessary to let the top voltage work itself off before you can depend on the voltage readings of individual cells.

Error in Last Month's Issue.

To the Editor:

The latter part of your answer to question by W. B. Hoschke on "Battery Troubles" reads as follows:

"A temperature of 30 deg. above normal (100 deg. Fahrenheit) would then show a gravity of 10 points above normal." This should, of course, be 10 points below normal, as the gravity falls with a rise in temperature.—F. H. Hopkins, Elec., Ill. Cent. R. R.

EDITOR'S NOTE.—The way this Question Box has grown in the last three months shows that it is filling a long felt want. There is probably no other department of the paper that has such wonderful possibilities for service as this, and we hope that both the "Man on the Job," as well as the department heads, will contribute both questions and answers. In this free interchange of ideas and experience, we will all benefit.

Practical Stunts

We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

A Home Made Coil Former.

For the benefit of those armature winders who make their own form wound coils, I will describe the former as developed and used in our shop. The coils are wound on a flat piece of wood or fibre, as is shown in Fig. 1, they are then slipped off and taped at the turn at the back end of the armature, as shown in Fig. 1. The coil is then placed on the former, as shown in

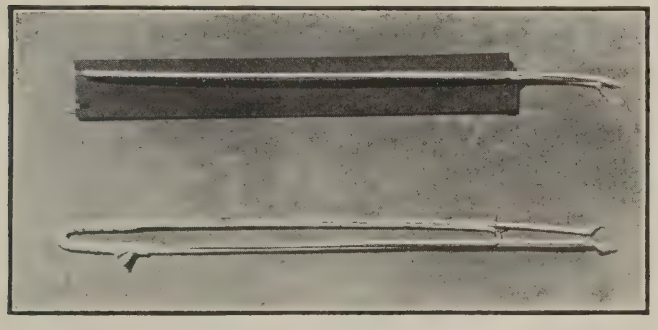


Fig. 1. Coils Are First Wound Over Piece of Fibre.

Fig. 2, and given its correct shape by pushing downward on the handle. One side of the coil is held by a slot in the cylinder and the other side hooks over a "U" shaped brass piece fastened to the handle. As the handle is drawn down, one side of the coil is carried forward with the handle, while the other remains

Fig. 2. This Is Then Placed on Former, which Is Clamped Solid by Vise on Block at the Bottom.

stationary on the cylinder. Meanwhile the coil is pounded into the correct shape to fit the form on the cylinder.

The former is made as follows:

Turn up a cylinder of wood having a length equal to that of the finished coil and a diameter equal to that of the armature core, minus the depth of one slot; across the face of the cylinder lengthwise cut a square groove ⅛ in. deeper than ½ of the armature slot, into this groove fasten a "U" shaped trough made of ⅛ in. brass and having a length equal to the straight side of the finished coil; one side of the coil should fit snugly into this "U" shaped piece. This forms a clamp for the lower side of the coil but to keep the coil from slipping out, take two pieces of brass ⅛ x ½ x 2 in. and fasten them like barn door buttons so that when they are turned crosswise their ends will project over the coil, as shown in Fig. 3, and hold the coil in place. From the ends of this clamp cut back the wood at an angle equal to the angle made by the ends of the coil, as shown in Fig. 3.

The handle and stretcher are made from two pieces

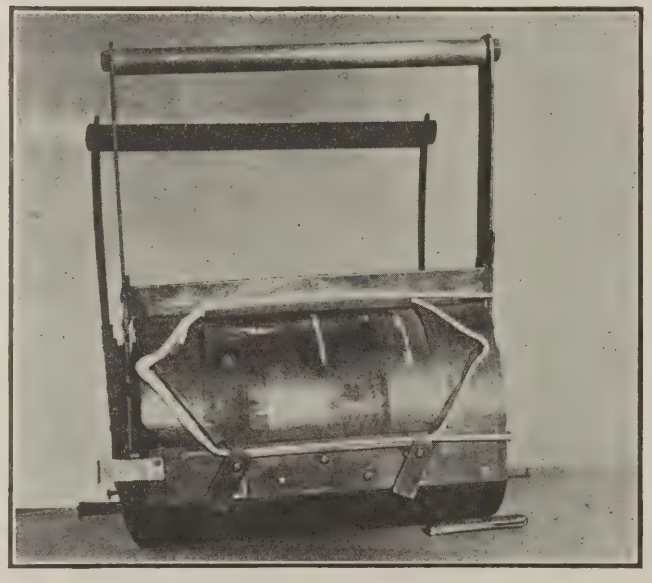


Fig. 3. Handle Is Then Pulled Down, Spreading Coil as Shown.

of steel ⅛ x 1 x 15 in. Pivot one end of each of these a little forward of the center of the cylinder ends and bolt the handle in place. Between these side bars rivet a piece of 8 in. steel 1½ in. wide, the lower edge of which will just clear the cylinder when thrown back. In the center of this cross piece and at the lower edge, fasten a second "U" shaped clamp to hold the other side of the coil.

Heavy screws can be turned part way into the wooden cylinder at the correct point to act as a stop against this cross piece so that the coil will be opened out only to the proper size. If a heavy oak plug is bolted to the under side of the cylinder this will provide a convenient means of clamping the former cylinder in the jaws of a vise and hold the whole apparatus rigid while operating.

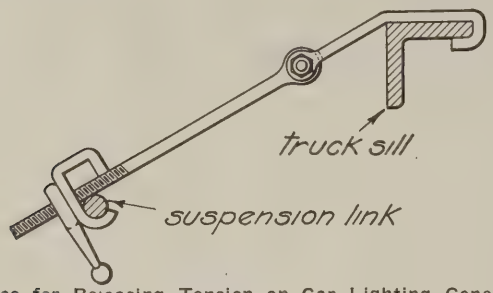
Two of the above formers for different types of armatures have been in use in our shop for three years and we feel that we could hardly do without them.—C. B. Jennings, Santa Fe R. R., Topeka, Kan.

Device for Releasing Belt Tension.

I find the device shown in the accompanying dia-

gram very handy for taking the tension off the generator belt when motoring the generator.

By throwing a hook over the end sill of the truck and hooking one of the suspension links as shown and tightening the hand nut, the tension is quickly



Device for Releasing Tension on Car Lighting Generator Suspension.

taken off the belt without disturbing the setting of the regular tension spring nuts. This saves a great deal of time in loosening and tightening of the tension bolts, but the main advantage is that the adjustment of the tension springs is not disturbed.

The device consists simply of two rods fastening together with a bolt, the one formed into a hook to fit a truck sill and for the other rod an ordinary tension rod with thread and hand nut is employed. A special steel washer is made of a rectangular piece of steel, one end of which is slightly hooked to catch the suspension link and the other end of which is bent around so as to bear the rod and keep the hooked washer straight.—D. D. Broyles.

Drilling Holes Through Plate Glass.

To the Editor:

I recently had occasion to drill 1 in. holes through the centers of plate glass used to admit high voltage wires to our main receiving station for power purchased from the local Electric Power Company.

Being unable to secure hydro-flouric acid and being desirous of getting the glass quickly (the acid would have required several days to eat through 3-16 inch glass) I tried drilling small holes around the circle, found it too slow; tried drilling a hole and then melting the glass, using an arc drawn between wires introduced through the hole and moving the arc around in widening circles as the hole was enlarged and found it too difficult to avoid breaking the glass so the following method was adopted:

A piece of copper tubing with outside diameter agreeing with the diameter of hole desired was revolved while resting on the plate glass where the hole was to be bored. A hole in the side of the tubing permitted the introduction of a half teaspoonful of powdered carborundum inside the tube which was moistened with turpentine. The carborundum working out over the glass beneath the end of the revolving tube was ground between it and the glass cutting a circle in the glass the exact size desired.

Fine powdered emery will cut in the same way but more slowly.

The speed of the tube is best at about 50 R. P. M.

Pressure should be exerted but slightly between tube and glass raising the tube frequently just sufficiently to permit fresh cutting powder to work beneath it. In drilling 3-16 inch thickness of glass the tubings should be ground twice to obtain full thickness of the tubing at the cutting end.

We heated one end of the tubing and drove in a tapered drift which flared it slightly and permitted us to drive the tube up over a spindle of a small drill press. An inch board with hole to clear the tube blocked rigidly several inches above the glass served as a guide for the tubing.

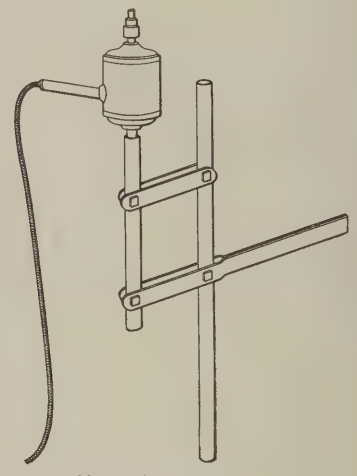
The tubing may be fitted over a drill or bit and rotated with breast drill or brace.

An hour is required to drill through 3-16 inch of glass when the tubing is driven by a machine as in the above instance and from three to four hours is required to drill by hand.—H. R. Bucks. Ch. Elec. Oregon Short Line.

Jack for Electric Drill.

To the Editor:

The accompanying sketch shows a simple drill jack which will be found very convenient and easy to handle by men who operate electric drills around cars and locomotives. This is made from pieces of 1-in.



A Home-Made Drill Jack.

pipe with side straps of ¼-in. iron as shown in the accompanying sketch. It is easily built, and is light and convenient for practical use.—T. A. Cummings, Chicago, Ill.

Communication.

To the Editor:

I was very much interested in your article on the Dick Axle Lighting System, published in the January issue of the *Railway Electrical Engineer*. Unfortunately, however, there are certain mis-statements in this article as follows:

On page 304 at the bottom of the left hand column, a statement is made that the magnetism of the shunt coil opposes that of the series coil. This is not the case, for on all regulators ever designed by us the magnetism of the series coil always acts in the same direction as the magnetism of the shunt coil.

The system as outlined by the diagram, Fig. 134, was abandoned by us some time ago; not because of failure of the equipment to work properly, but rather because of the high cost of construction.

There are to be sure, especially in Austria, a large number of regulators like that shown in Fig. 135 which have been in operation for a long time and are giving excellent service. The degree of efficiency in this service is shown by the fact that several passenger coaches inspected for the first time after being in use 15 months, were still in perfect working order, whereas the lighting service during that period had been excellent.

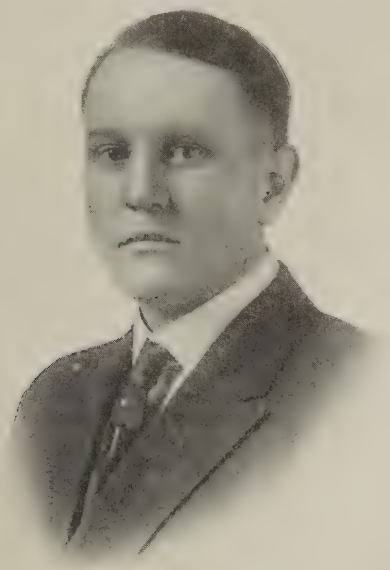
Vienna, Austria, Feb. 19th, 1914. Emil Dick.

EDITOR'S NOTE—The manuscript with photographs and diagrams of the new Dick system, submitted by Mr. Dick, will be used as the basis of another article descriptive of this system at an early date.

General News Section

D. C. Wilson.

Upon the resignation of Mr. A. J. Collett, to accept a position in San Domingo, as previously announced in these columns, Mr. D. C. Wilson, formerly Mr. Collett's assistant, was appointed electrical engineer of the Union Pacific R. R.



D. C. Wilson.

Mr. Wilson finished the electrical engineering course at the Nebraska State University in 1907, at which time he went with the Stone & Webster Co. He was employed largely, while with that company, on the Union St. and Georgetown Power Plants at Seattle. Later he worked in the Government Navy Yard at Bremerton, Wash., until the completion of electrical work on the Battle Ship "Nebraska." Then he entered the employ of the Pacific Electric Co. at Los Angeles, wiring street cars and interurban trains, in which the multiple unit system was employed.

He later worked for the Independent Telephone Co., at Omaha, Nebr., until entering the employ of the Union Pacific Co., in 1908. His first work with this later company consisted of wiring new car shops which were at that time under construction. He was later promoted in this organization as follows: (1) Assistant in charge of electrical construction, (2) electrical draftsman, (3) electrician in charge of electrical construction and maintenance, (4) electrical engineer.

Joint Meeting of Ill. Engr. Soc. and Ry. Signal Asso.

There will be a joint meeting of the Railway Signal Association and Illuminating Engineering Society at 8 P. M. Friday evening, April 10th, in the rooms of the Western Society, 17th floor of the Monadnock Building, Chicago, Ill.

Three papers will be presented, as follows:

"Illumination of Railway Signals," by Thomas S. Stevens, Signal Engr. of the Santa Fe.

"Psychology of the Eye and Its Relation to Signal Affairs," by Dr. Nelson N. Black, Milwaukee, Wis.

"Signal Lenses," by Dr. H. P. Gage, Corning Glass Works.

New Electric Locomotive for Detroit River Tunnel.

The Michigan Central Railroad has recently purchased four 120 ton 404-600-volt electric locomotives from the General Electric Company for use in the Detroit River Tunnel.

Oliver Elec. Mfg. Co. Extend Quarters.

On account of large increase in business the Oliver Electric & Mfg. Co. of St. Louis have recently extended their shop so as to include an adjoining building.

The arrangement of the new shop separates entirely the mechanical and electrical departments. All of the mechanical department remaining in the old quarters and the electrical occupying the new. The manufacturing space is more than doubled. They are also installing some new machinery and now have a modern shop in every particular, and are well adapted to the particular work they handle.

The Oliver company specialize on repairing car lighting equipment and it is interesting to learn that orders are being received from Portland, Ore.; Kansas City, Ft. Worth, Chicago, Buffalo and Boston.

U. S. L. Chicago Office Moved.

The Chicago Branch Sales Office of the U. S. Light & Heating Co. has been moved from 1013 Peoples Gas Building to 2335 State street.

This change brings the U-S-L Chicago Sales Office and Service Station into the same building.

The Railway Department of the Chicago Office is now under Mr. H. A. Matthews; Mr. R. E. Stuntz has charge of the Battery and Starter Department, and the Service Department is being looked after by Mr. H. M. Emerson.

Instructions for Mounting Axle Pulley.

The American Pulley Company of Philadelphia has recently issued a booklet giving instructions for installing American pressed steel axle pulleys and bushings in railway car lighting service.

This booklet, which is a vest pocket edition and printed on heavy durable paper, contains much information which is of interest and value to the car lighting man. It should be in the hands of every man who has anything to do with the application of axle pulleys.

Copy will be sent upon request to the manufacturer.

New Consolidated Car Lighting Bulletin.

The Consolidated R. E. L. & E. Co., of the Hanover Bank Bldg., New York, have just issued a new bulletin on car lighting equipment showing their type of "L" regulator and type "D" dynamo.

The booklet contains much information of interest

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25 years of specializing in the supply of electrical equipment portant factor in railroad work. Your entire requisition can be covered with one order and you receive the goods *"House of Service"* serve you.

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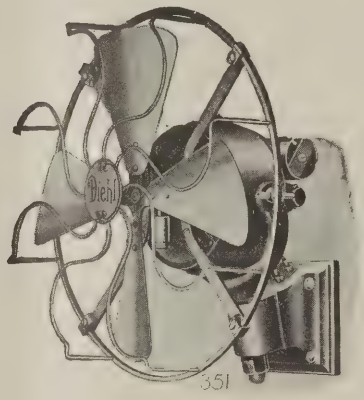

Diehl Car Fans give a finishing touch to passenger comfort. Designed specially to meet the severe conditions of this service. The fan body is readily removed from the base without disturbing the wiring. Pleasing in design.

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and value to all car lighting men as it goes into considerable detail and is profusely illustrated. It explains fully the operation of the type "L" regulator, which employs the rocker contact shoe principle in both dynamo and lamp regulators. It also shows detail of parts such as brush rig, interpole, pole changer, section through generator suspension, etc., with descriptive matter about each.

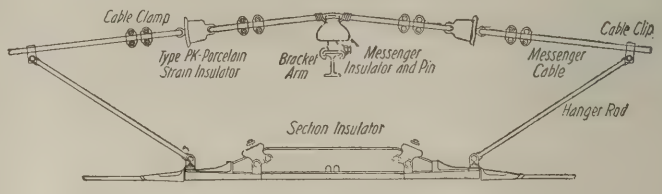
New Types of Porcelain Strain Insulators.

To meet the severe requirements due to the increasing weight of overhead construction two new types of porcelain strain insulators have been developed by the Westinghouse Electric & Manufacturing Company. These are a combination of a metal cap to give the necessary strength and a porcelain skirt to furnish the required dielectric strength.

The metal parts of these insulators consist of a malleable iron cap, a drop forged steel eye bolt, and a malleable iron sleeve by which the eye ball is securely fastened.

The metal and porcelain parts are cemented together with a high grade Portland cement. The cemented surfaces are provided with carefully determined corrugations which prevent failure, except by the actual shearing of the cement. The skirt of the porcelain is provided with corrugations on the under side to give additional creepage surface.

Two types of these insulators are made, the PK and the PK-1. The metal parts of the type PK insulator are sherardized and those of the larger size, types PK-1, are not galvanized. The type PK Insulator is especially used for insulating cables when the working load does not exceed 1,600 pounds. Being tested at 5,000 pounds the types PK and PK-1 are generally used for heavy service, such as dead ending high strength steel messenger cables, having a working load of 4,000 and 8,000 pounds respectively.



Showing Manner of Applying New Strain Insulators.

The drop forged eye bolt of the type PK-1 has side projections so that if two or more insulators are used in series they cannot swing more than a few degrees, thus avoiding the danger of breaking the porcelain skirt due to striking the cap of the adjacent insulator.

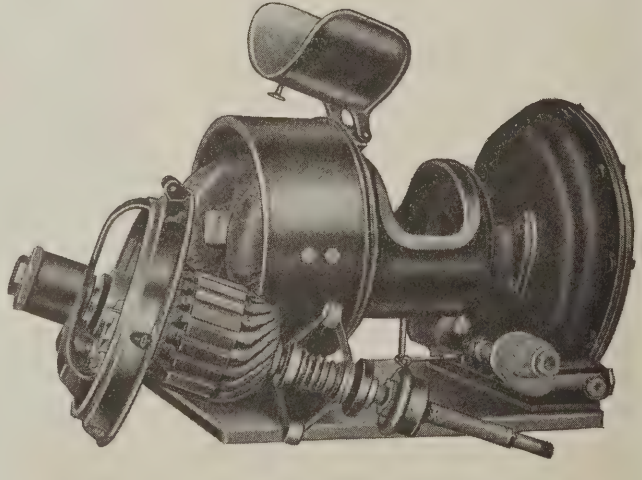
New S. K. F. Ball Bearing Bulletin.

The S. K. F. Ball Bearing Company, of 50 Church St., New York, has recently issued a special bulletin on the application of ball bearings to railway car lighting generators. The bulletin goes into considerable detail showing the application of these bearings to the Consolidated, U. S. L., Safety and Gould axle lighting equipments.

The S. K. F. bearing has a double row of balls, each operating in a separate groove on the inner raceway, the outer raceway having a spherical surface permits the shaft to assume any desired position without binding the bearing.

The bulletin explains in detail the technical features of the bearing and gives information as to dimensions, etc. Copy of this will be sent to any railroad man upon request to the S. K. F. Ball Bearing Company.

Facts are Stubborn Things



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Let us give you definite facts and figures from actual service.

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RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Illumination of Railway Signals

It is interesting to note the rapid strides which are being made in the application of electrical equipment in all branches of railway operation. Probably the most recent development, and by no means an unimportant one, is the use of electric lamps for illuminating railroad signals. With specially constructed lamps, where the filament is concentrated in helical form so that practically the entire light flux of the lamp is located in the focal zone of the lens, it is found that a one candle power electric lamp will illuminate the signal so brilliantly that it can be readily distinguished at a distance of 2 miles. This current consumption is so low that it has been decided to burn the lamps day and night and thus eliminate the complication of control circuits.

These small candle power lamp installations were designed to operate in connection with the usual semaphore systems, simply re-placing the oil flame as illuminant, but even a more radical departure from past practice is found in the successful trials of powerful electric lamp signals for both day and night use to replace entirely the semaphore arm with its complicated operating and control mechanism. The real problem in this revolutionary idea seems to be to arrive at the proper intensity of illumination of the signal so that the lamp will be clearly discernable in the day time with the sun shining brightly and, at the same time, will not be too brilliantly illuminated at night.

In numerous tests on the Pennsylvania railroad at Pittsburgh where 20 watt mazda lamps with concentrated filament have been used in connection with 10 in. lens, even in the smoky atmosphere prevalent at Pittsburgh these lamps are easily visible by day or night at from 4,000 to 5,000 ft.

It is interesting to note that in connection with the Philadelphia suburban electrification it was originally decided to employ transverse bridge supports for the overhead catenary construction and in order to prevent the interference and liability of error in observing the semaphore arm signals against the background of cross supporting beams, it was decided to employ the electric lamp signal for both night and day. Although experiments subsequently proved the desirability of using transverse cable supports and poles instead of transverse bridges, the advantages of the electric day signal are realized to be so important that the original plan of using this type of signal has been adhered to.

If practical experience proves this system of signalling to be as effective as preliminary tests would indicate it will, no doubt, have a revolutionary effect upon all future signal installations.

Constant Potential Charging

There has been much discussion of late pro and con on the matter of constant current versus constant potential battery charging. In practically all lines of battery service it is found that the constant potential method of charging can be employed with many advantages, but the chief of these seems to be that the gasing overcharge and the high current rate near the end of charge is eliminated because of the inherent taper characteristics of the constant potential method which automatically reduce battery charge as the counter e.m.f of the battery rises during the charge. This will produce a heavy current flow at the beginning of charge, due to the great difference between the constant potential impressed and the counter electro motive force of the storage battery. This rush of current, however, does not seem to damage the plates to any appreciable extent, probably because of the fact that it can not produce any gasing whatever at the beginning of charge.

In applying this principle to yard charging plants it was found, as outlined in an article on this subject in our March issue, that the constant potential system is considerably more economical to install than is the constant current system for charging each battery individually. The ratio of total costs for a particular installation were $106,000 for the constant current and $74,000 for the constant potential, although in certain comments made by us in that issue this order was reversed, which error we would like to correct at this time.

In addition to a saving in first cost of $32,000, the cost of power wasted in the constant current system figured on a basis of 2c per k.w.h. would amount to something over $1,000, which capitalized at 5 per cent would make an added difference between the two systems of $30,000, or a total difference in favor of the constant potential system of something over $60,000 on a plant which the cost of the constant potential system amounted to but $74,000. This is imposing evidence in favor of constant potential system, but when the saving in battery depreciation due to the elimination of gasing is considered, the further advantage of this system is evident.

New York R. R. Club Electrical Night

Swiss Electrification

A commission composed of representatives of the railroads, government, manufacturers and power companies is working jointly on the problem of complete electrification of the Swiss Railways. Independently of this, however, it has been decided to electrify the St. Gothard Line, 68 miles long, with heavy grade and 10 mile tunnel at the divide. This line will connect Italy with Continental Europe.

Savings in operating expenses is not a deciding factor in Swiss Railway electrification, because steam operation has not reached its limit; it is rather because of the large percentage of tunnels, scarcity of coal and bountiful supply of water power. The speaker, Mr. Stockar, states that the elimination of smoke will make travel more pleasant and safe, and will also reduce maintenance expense on road bed in tunnels.

Locomotives will haul 400 ton trains on up grades of 2.6% at 32 mi. per hr. and at 45 mi. per hr. on level track. High speed is not an important feature in Swiss operation.

Norfolk & Western Electrification

Mr. Gibbs then spoke on Norfolk & Western electrification. First locomotive was recently tested and balance is being constructed. Complete installation will be ready by November, 1914.

Section to be electrified covers 30 miles of line on western slope of Allegheny divide, including 4000 ft. tunnel at the top. This is the heaviest railroad electrification ever built. Locomotives will deliver draw-bar pull of 100,000 lbs. Each half-locomotive weighs 130 tons, with 110 tons on the drivers. Single phase a.c. system to be employed, with 11,000 volts on the trolley. Three-phase motors are used on locomotive, which give it constant speed and power regenerative characteristics which are valuable on this line. A phase splitting device on the locomotive converts the power from single-phase current received from the trolley to three-phase current for use on the motors.

Penn. R. R. Electrification at Philadelphia

11,000 volt a.c. system operating multiple unit car trains, without locomotive, will be employed on the Paoli suburban division. Length of this division is 20 miles, 4 track road. Operating suburban trains on multiple unit car principle will eliminate locomotive and empty train movements through the throat of the Broad Street station and reduce congestion at this point. Standard steel cars will be used and one truck of each equipped with two 225 h.p. single-phase motors.

An experimental section of the line has been equipped with various types of trolley construction and thorough tests made. Double trolley with single catenary construction, supported by transverse catenary cables with steel poles at 300 ft. intervals instead of supporting bridges has been decided upon.

An experimental car has been equipped with four 225 h.p., d.c. motors, rectifier, transformer, and a.c. control circuits, which makes a 1000 h.p., a.c., d.c. locomotive. Car is now operating experimentally on the New Haven with good results.

Mr. Murray described new system employed on New Haven for eliminating inductive disturbances on adjacent telephone and telegraph lines. System adopted is similar to the old three-wire 220-110 volt circuits. Total voltage 22,000, with 11,000 between trolley and rails, which act as neutral. This practically eliminates the objection to a.c. electrification on the grounds of inductive troubles.

Mr. N. W. Storer then described tests made on first locomotive for Norfolk & Western. Maximum power available for tests gave a total of 82,000 lbs. standing draw-bar pull without slipping wheels.

The March meeting of the New York Club was the annual electrical night and the principle feature of the evening was an address on Swiss electrification, by Mr. Emil Huber Stockar, consulting engineer on the electrification of the Swiss State Railways. Mr. C. O. Mailoux, president of the American Institute of Electrical Engineers, introduced the speaker as a man who had had wide experience in electrification matters in Europe, and who had been selected by the Swiss government as special consulting engineer for the proposed extensive electrification of the Swiss Railways.

Swiss Electrification

In opening his address Mr. Stockar mentioned the development of electric traction in Switzerland, which dated back as early as 1894. In 1899 a three-phase line was built and shortly after an 800 volt d. c. third rail system was constructed. This was followed shortly with the three-phase electrification of the Simplon tunnel. Of recent date the 1500 volt single-phase electrification of the Lotschberg Railway is the most important. He stated that for some time a government committee has been at work in Switzerland investigating the subject of electrification of the Swiss lines generally and also on certain main lines particularly. This committee was formed under the auspices of the Society of Electricians of Switzerland and the Federal State Railways and certain manufacturers and power companies were represented on the commission. Although the commission is not a government commission, nor does it report to the government, it is supported financially by the government and the State Railways jointly.

In May, 1912, the commission reported regarding the practicability of electrifying the St. Gothard Line and recommended the adoption of the single-phase 15,000-volt, 15-cycle system. This report showed a considerable saving to be realized by electrification, based upon the anticipated tonnage which may be expected by the time electrification is completed.

Of the 319 km. (198 mi.) of line already electrified in Switzerland, 210 km. (131 mi.) were single-phase and of this mileage 91 mi. were operated at 15 cycles. The standard gauge railways of Switzerland include 3400 km. (2110 mi.) of which 2800 km. (1740 mi.) are owned by the government.

The Federal Railways have studied the problem of their own electrification more or less independently of the above-mentioned commission and have purchased water power rights and proceeded with electrification of a section of the St. Gothard Line. This section includes 110 km. (68 mi.) and has long heavy grades with an unusual percentage of tunnels, including the main tunnel at the top of divide which is 16 km. (10 mi.) long. There is a well established traffic on this line, both in passenger and freight and this is

increasing at a rate which will make the traffic in 1918 about 35% greater than in 1911.

The speaker pointed out, however, that the saving in operating expenses is not the deciding factor in the Swiss electrification at the present time, for the reason that steam operation has not yet reached the limit of its capacity under present conditions. It is rather because of the large percentage of tunnels on these railways with resultant smoke nuisance, and also because of the general public interest in the substitution of electricity for steam, since Switzerland has abundant water power and no coal, that electrification is so popular. On the St. Gothard Line, moreover, if the steam equipment was to be made of large capacity it would have been necessary to re-inforce or re-place almost all of the bridges; this will not be required with electrical operation.

The principle objects to be obtained in the St. Gothard electrification are as follows:

(1) Speed on heavy grades can be increased so as to increase the traffic capacity to a much greater extent than would be possible with steam; (2) trains can be handled by electric locomotives more expeditiously than with steam and the total number of locomotive miles reduced; (3) where with steam locomotives it is necessary to have two pulling engines and one pushing engine on each train, one of the pulling engines will be eliminated; (4) the elimination of smoke in the numerous long tunnels will improve conditions for both train crews, passengers and men at work on track and will undoubtedly reduce the cost of track maintenance in tunnels.

Although the single-phase system has been recommended no final decision is necessary at this time, as further data will be gathered while the necessary power plants are under construction. If the single-phase system as recommended is finally adopted, the line will be operated at half voltage (7500 volts) during the transition period from steam to electricity in order to avoid troubles from smoke and soot deposit upon insulators. The transmission line voltage will be 60,000 volts, with 30,000 volts from each wire to ground. This will be stepped down at sub-stations to the trolley line voltage of 15,000 volts after the system has been completely installed.

The passenger express locomotives will be required to haul trailer loads of 400 to 420 tons at 50 km. (31 mi.) per hour on grades of 2.6%. They will have a capacity of approximately 3000 b. h. p. continuous rating. The freight locomotive will be required to give a draw-bar pull or push of 10,000 to 11,000 kg. (22,000 to 24,000 lbs.) at a speed of 45 km. (24 mi.) per hr.

He stated that although the locomotives were required to develop a certain high speed on level track this feature is not at all important because of the great percentage of line on heavy grade and curvature. He said that there were probably not more than 300 miles in all Switzerland where a speed of 55 miles per hour would be of any great value. What is needed is to get as high speed on heavy grades as is compatable with the character of the road and economical use of the power. It is unfortunate that the draft-gear of Swiss rolling stock is not of sufficiently heavy capacity so as to make is possible to get the full benefit of electrification in the heavy draw-bar pull possible with electric locomotives. Under present conditions the capacity of locomotives is limited by the capacity of the draft-gear.

Mr. Gibbs on Norfolk & Western Electrification

Mr. George Gibbs, consulting engineer for the Pennsylvania Railroad, then spoke briefly on the Norfolk & Western electrification, the first split-phase locomotive for which has just been tested at Pittsburgh. Mr. Gibbs stated that the N. & W. Ry. electrification is probably the heaviest electric traction scheme proposed anywhere in the world. There is a large coal movement from the fields on the western slope of the Allegheny mountains easterly to Tidewater. This must be taken up the western slope of the Allegheny mountains and it is this section of the line which is being electrified, including a 4000-ft. tunnel at the top. This tunnel is the limiting factor in capacity of the entire road and the alternatives for electrification to relieve congestion are to double track the tunnel or to build a relief line, both of which would be very expensive.

It is found that electrification of the existing tracks will not only provide the desired increase in capacity, but will afford savings in operating costs which will pay interest and depreciation charges and leave a large surplus besides.

On the 30-mile section to be electrified, 65,000 tons a day are carried eastbound, of this, 48,000 tons is revenue business. With steam operation it is customary to use three mallet engines, two in the front, and one as pusher, to haul a train of 3250 tons on a 2% grade. This combination will be replaced by a front and rear electric locomotive, each weighing 130 tons, with 110 tons on the drivers. The guiding wheels were added on these locomotives because of the excessive amount of curvature, about 40% of the entire line being on curves up to 12 deg.

The maximum draw-bar pull of one of the single units, two of which make up a locomotive, is 48,000 lbs. during acceleration and 42,000 lbs. normally on a 2% grade. This gives, therefore, a draw-bar pull on starting of approximately 100,000 lbs., which is about five times the allowable limit on the State Railways of Switzerland, as outlined by Mr. Huber. The system adopted is the single-phase with an overhead trolley wire carrying 11,000 volts; on the locomotive the single-phase current is converted to three-phase by a phase-splitting device, thus allowing three-phase induction motors to be used, a type which has certain important advantages in re-generation and speed control which are important for this traffic.

Power is transmitted at 44,000 volts and is transformed in sub-stations along the line to the working pressure of 11,000 volts. The power house is a steam plant and contains three 9000 k. w. turbogenerators. The foundations for the catenary line are finished and the erection of steel will begin immediately. It is expected that the complete installation will be ready for operation by November, 1914.

Mr. Gibbs on the Philadelphia Suburban Electrification

Mr. Gibbs continued his address stating that the Pennsylvania Railroad had reached its capacity in the Broad Street station at Philadelphia, so the question of enlargement has been given consideration. It was found that by the electrification of the suburban service a large number of empty train and locomotive movements might be elminated. The principle point of congestion is at the junction of the six suburban routes in the yard outside the station. By electrification it will be possible to save from 16 to 20% of the throat movement, since the multiple unit cars will be able to double out of the station, without going to the coach yards and roundhouse.

Initially the Broad Street Paoli Line will be electri-

fied only, this consists of 20 miles of 4 track road, but will be followed without doubt soon by the electrification of the Chestnut Hill branch as soon as business conditions warrant. He said that this electrification was not being considered for reasons of economy, but was purely a case of emergency.

Electrification will be on the single-phase a. c. system with 11,000 volts on the trolley. Trains will consist of multiple unit motor cars, each car being of standard design and having two 225 horse power single-phase motors on one truck only.

Mr. Gibbs spoke of an interesting experiment which is now being carried out in using direct current locomotives with a rectifier on high voltage a. c. trolley

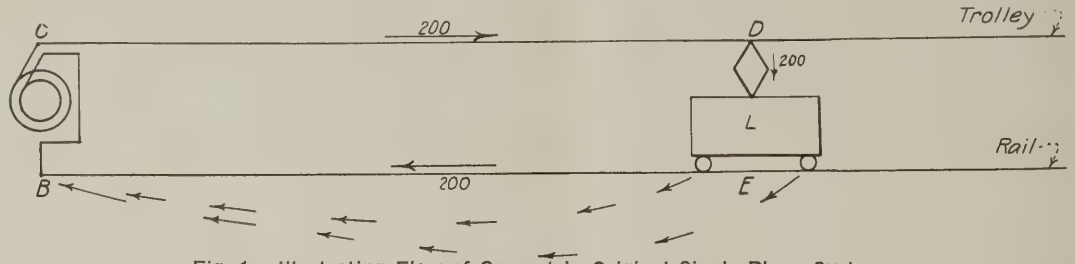


Fig. 1. Illustrating Flow of Current in Original Single Phase System.

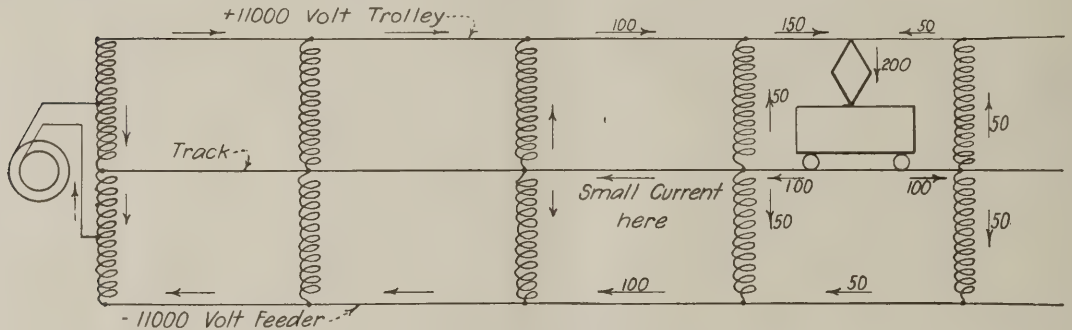


Fig. 2. New System of Distribution. Note That.

circuit. A standard steel combination car was loaned to the Westinghouse Company some time ago and this has been equipped with four 225 h. p. direct current motors; a mercury rectifier, and alternating current control equipment with transformer which produces, in effect, a 1,000 h. p. a. c.-d. c. locomotive. Alternating current is taken from the 11,000 volt trolley, passes through the transformer and the control apparatus to the rectifier, where it is transformed to direct current for use in the d. c. motors. This car was thoroughly tested at Pittsburgh and has lately been sent to New York, where it is now running in road service tests on the New Haven. The experiment appears very promising and further widens the field of single phase traction for railroad service.

Mr. Gibbs in closing his remarks deplored the tendency on the part of American manufacturers in concerning themselves unduly as to what type of system was to be selected for any electrification rather than confine their activities solely to the manufacture of apparatus specified by the railway engineers.

Remarks by A. H. Armstrong

A. H. Armstrong, engineer, Railway Department, General Electric Company, then addressed the meeting and disagreed with Mr. Gibbs that the manufacturer was prejudiced in the matter of selection of system to be used. Such engineers are afforded exceptional opportunities to become familiar with both the design and operation of electrical machinery and auxiliary apparatus and furthermore, have been most liberal in publishing all facts as soon as their accuracy has been well established. As an example of the high grade consulting engineering work done by the manufacturers, he mentioned the 2,400 volt d. c. electrification of the Butte, Anaconda & Pacific Ry., on which trains of 4,000 tons were being hauled.

Mr. Murray on Elimination of Inductive Interference

W. S. Murray, Consulting Engineer of the N. Y., N. H. & Hartford R. R., then discussed briefly the new 22,000 volt balanced distribution system as described in our Feb., 1914, issue, which has recently been installed on the New Haven road to eliminate the inductive disturbances on adjacent telephone and telegraph lines. Mr. Murray stated that this was the last straw of the objections to the a. c. system and this has finally been removed in a most satisfactory manner.

With the system as formerly employed, the current would flow from the generator or sub-station, over the trolley to the locomotive and return through the rails and ground. Thus a loop of large dimension would be formed which, with the heavy current and high voltage employed, would cause serious inductive effects on adjacent lines. This is illustrated by the diagram Fig. 1.

The present system is something similar to the old three wire d. c. system and the rails serve as the neutral connection. We have 22,000 volts between trolley and feeder but only 11,000 volts between trolley and rail, as shown in the accompanying sketch. Auto transformers are installed along the line at intervals of two miles and connected between trolley, rails and feeder, as shown in the sketch. Current is then transmitted from the sub-station to transformers adjacent to the locomotive, at 22,000 volts, the 11,000 volt current being fed from the auto transformers to supply the locomotive.

It will be noticed, however, upon studying the diagram that the two, and possibly more, transformers adjacent to the locomotive will operate in parallel and will feed current to the locomotive. It should be noticed that these currents come to the locomotive from both directions and accordingly the magnetic inductance of the current in this loop will be neutralized.

He stated that the day that the new system was put into effect he personally used a telephone par-

alleling the right-of-way for 25 miles. With the ordinary system it was impossible to hear distinctly, but with the new system he could distinguish no difference in the clearness of the telephone transmission while the load fluctuated between zero and 23,000 k. v. a.

Mr. Storer on Norfolk & Western Locomotives

N. W. Storer of the Westinghouse Elec. & Mfg. Company then described the articulated double truck locomotives being built for the Norfolk & Western Ry. and showed a number of lantern slides of the locomotives. This locomotive has side rod drive as is used in standard steam locomotives, and transmission from each pair of locomotives to side rod is obtained through a jack shaft. The first locomotive has been under test for the past six weeks at Pittsburgh and the entire system operated perfectly.

The dynamometer tests showed up some very interesting results. The tractive effort of the first locomotive weighing 140 tons during acceleration of the trailing load of 1,280 tons increased gradually to 45,000 lbs., meanwhile the speed of the train increased smoothly. On standing test there was not enough power available to show the full capacity of the four motors, but with motors No. 1 and No. 2 alone, the tractive effort on starting (dead pull) came up to 39,000 lbs., and with motors No. 3 and No. 4 alone, 43,000 lbs., was secured without slipping the wheels. The balance of the locomotives for this electrification are now being built as rapidly as possible.

Illumination of Railway Signals

In the electric lamps recently employed for lighting signals, it is found that a one c.p. lamp with its filament concentrated at the focal zone gives a more effective illumination of the signal than a 16 c.p. lamp with an ordinary filament. The current consumption of the small lamp is so low that lamps are never turned off, so complication of control circuit is eliminated. Electric lamp signals are now employed for day signalling as well as night, replacing the semaphore arm with its complicated operating and control mechanism. It has been decided to use this type of signals on the new electrified section of the Pennsylvania R. R. at Philadelphia. Electric lamp signals are located below the transverse overhead support construction for trolleys. Signals with 10 in. lenses and 25 watt lamps on test at Pittsburg, can easily be seen by day or night for 5000 ft.

At the joint meeting of the Railway Signal Association and the Chicago Section of the Illuminating Engineering Society, held in Chicago recently, three papers on the subject of illumination of railway signals were presented and discussed.

Mr. Thomas S. Stevens, signal engineer of the Santa Fe, presented the first paper. He stated that the development of signal illumination has been along three definite lines: 1, kerosene lamps; 2, electric lamps; 3, acetylene lamps. The first oil lamps and burners were crude affairs and there was no correct understanding of the requirements of ventilation, combustion, protection from wind, etc. Later developments of the long burning lamp made it possible to extend the period of trimming to once a week where pure paraffin oil is obtainable; where western oils, which contain a certain amount of impurity, are used, this impurity cakes at the tip of the wick and the lamp must be trimmed at least twice a week.

Wherever practicable electric lights have been introduced. The first lamps to be used were ordinary 16 c. p. carbon lamps, but it was found that these lamps gave out far more light than was required, and moreover that since only a small portion of the lamp filament came at the focus of the lens, only a very small part of the total light emitted by the lamp would be utilized by the lens. It was soon found that an electric lamp of one candle power, with a filament concentrated near the focal point of the lens, would give even a far more powerful beam of light down the track than would the old style oil lamp, the candle power of which is only but slightly over one candle power, but the flame of which covers a larger area than does the filament of the electric lamp. Signals equipped with 1 c. p. electric lamps can be seen for a distance of two miles, largely because of the great concentration of the light at the focal center, which gives a beam of light with rays nearly parallel.

At the larger plants power is taken from dynamos direct, or from some local supply, but on smaller signal installations current is taken from storage batteries which are charged by gasoline engine-driven units. The energy consumption of the one candle power lamps is so small, being but slightly over a watt, that a very small battery would provide light and power for a fair sized plant for two or three days at least. In many installations, since the cost of current for signal lamps is so small, the lamps are burned all day and this eliminates all complicated control system for turning the lamps off and on and insures greater reliability.

Recently there has been an acetylene flashing lamp developed which seems to have many points of merit. It is claimed that the flashing of the light has an effect on the eye which renders the signals more distinct. A permanent magnet valve arrangement is provided which controls the operation of the flash with apparently great reliability. Lenses have been developed to such a perfection today that it is found practicable to illuminate signals so that the different colors can readily be distinguished in daylight at 2,000 ft. This is, of course, only possible where electric light can be used, but it provides a cheap and efficient signal for electric roads or steam railroads where electric power is available. All the complicated mechanism necessary for the mechanical operation of signal arms are eliminated and are replaced by simply the electric lamp with its control circuit.

In the majority of cases two 25 watt lamps are used with an 8 in. lens. It would appear that the chief problem with this type of signaling is to provide a light signal which would be sufficiently visible in bright sunlight, yet which will not make the signal too prominent at night.

In concluding his paper Mr. Stevens called attention to the present development in signal lenses, particularly as to the color of light emitted.

Mr. J. S. Hobson, of The Union Switch & Signal Co., opened the discussion on this paper and stated that 20 watt lamps have been used very successfully in and around Pittsburgh in connection with 10 in. lenses. He said that these are visible by day or night in the smoky atmosphere prevailing there at distances from 4,000 to

5,000 ft. He stated that a special lamp with concentrated filament, which can be placed at the focal center of the lens, is used.

Mr. G. L. Walters, of The Adams & Westlake Co., spoke of the importance of purity of oil used in signal lamps; with pure paraffin oils obtained from Pennsylvania little trouble is experienced, but with western oils which contain a certain amount of impurity, apparently in solution, a cake is formed on the tip of the wick which causes trouble.

He stated that with electric lamps it is far more important to have the lamp filament at the focal zone than it is to have a powerful lamp. He pointed out that a one c.p. lamp with filament concentrated in the focal zone will give more effective illumination of the signal than a 16 c.p. ordinary filament lamp.

M. G. Lloyd called attention to the helical filament lamp as making an ideal source of light for signal work since practically the entire filament can be placed in the focal zone of the lens.

In closing the discussion Mr. Stevens said that oil lamps are still most generally used; electric lamps are used to the extent of about 4 or 5 per cent; acetylene lamps are being used on a few railroads only.

Nelson M. Black, Milwaukee, Wis., then presented a paper on the physiology of the eye and its relation to railway signaling. He showed numerous lantern slides of the structure of the eye and showed how form vision differs from color vision. Form vision depends upon the size of the image on the retina, the amount of light reflected from it, and the contrast from its background. Observations have shown that a person with normal vision can readily distinguish the form and outline of an object if the angle subtended by it at the eye is more than 5 minutes, or if in the case of an object, such as a letter, this can be discerned with a one minute angle overall. Railroad officials have established a minimum standard of entrance for engine men and firemen, requiring an ability to read letters which subtend a 5 minute angle at 20 ft.

As to color, he explained the theory of color and stated that the average eye can distinguish six separate colors in the visible spectrum, red, yellow, green, blue-green, indigo-blue and violet. The ability to distinguish these different colors depends upon three properties, the hue, the saturation, and the intensity of the color. Hue is the color; saturation, the purity of the color, i. e., how much white light is emitted with it; and intensity is the candle power of the light. He exhibited numerous roundels of different colors and showed the importance of railway men being free from subnormal color perception, commonly known as color-blindness.

His paper also contained a table showing the order of spectrum colors, the wave lengths corresponding, also a table of spectro photometric analysis of roundels of the various colors of medium intensity as specified by the R. S. A.

M. G. Lloyd discussed the effect of atmospheric absorption in signals of different colors and although experiments have shown that red is most absorbed by fog, a reddish light is discernible at a greater distance than light of a shorter wave length.

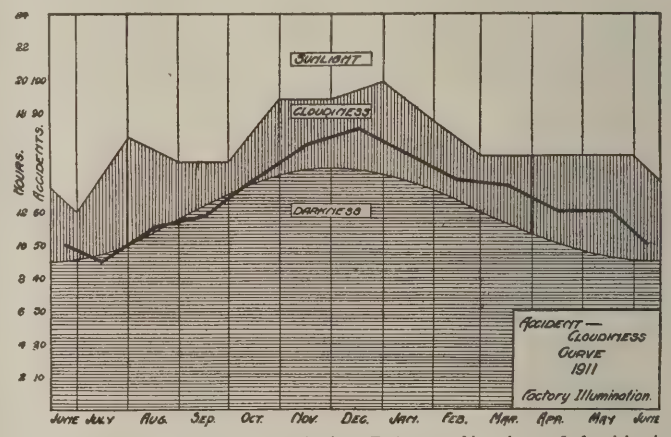
C. C. Anthony, of the Pennsylvania Railroad, spoke of the Paoli electrification at Philadelphia, where it was originally planned to suspend the overhead catenary construction by steel bridges. Since these bridges, however, would obstruct the view of signals on the signal bridges, it was proposed to abandon the use of semaphore signals and to install electrically lighted signals in the form of large lenses placed under these bridges.

After a series of tests of different types of overhead construction, it was decided to use span wire transverse supports for the catenary instead of steel beams as originally planned, but the advantage of using light signals instead of semaphores was believed to be so great that the original plan of using electric signals instead of semaphore arms would be adhered to.

Mr. H. P. Gage, of the Corning Glass Works, then presented a paper on signal lenses, in which he described and illustrated the various lenses used in signal work, showing the difference between the optical, inverted, wide angle and spread lenses. He explained the methods which should be followed in the types of lenses for different uses.

Good Light as Accident Insurance

The accompanying curve taken from the paper on "Factory Lighting," presented before the annual meeting of the Illuminating Engineering Society, by Messrs. M. H. Flexner and A. O. Dicker, clearly shows the influence of lighting, or rather lack of lighting, upon the number of accidents which occur in factories or shops, only fairly well lighted. Not only does good lighting improve the physical condition of the workman, as well as his ability to work better and faster,



Curves Showing the Direct Relation Between Number of Accidents and the General Illumination Provided.

but it also greatly decreases his liability to accident. There is no doubt that the saving in accident damages alone will more than warrant the installation of a proper lighting system, to say nothing of the increased output and efficiency of the plant.

Furthermore,no lighting system should be considered complete until some definite provision has been made for a regular cleaning schedule for both lamps and reflectors, for no matter how effective a lighting system may be installed, it will rapidly depreciate in service if not cleaned.

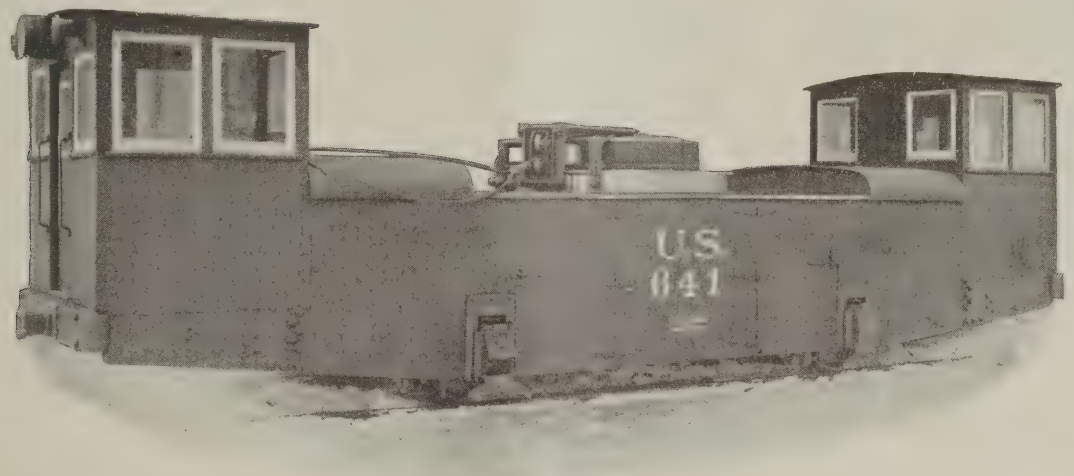
Practical Battery Talks.

We have arranged for two practical battery talks to be given before the May and the July meetings of the Railroad Electricians' Club, as described on page 406. Mr. H. M. Beck, of the Electric Storage Battery Co., will give the first talk on the "Lead Storage Battery," Tuesday, May 19th, 8 p. m., 17th floor of the Monadnock Bldg., Dearborn and Jackson Blvd., Chicago. Note the change in place and date of meeting. Every car lighting and signal battery man within 200 miles of Chicago ought to make a special effort to attend this meeting, for it will be something worth while.

Electric Towing Locomotives for Panama Canal Locks

ABSTRACT

All ships will be towed through the Panama Canal Locks by means of four electric locomotives, operating on a rack. Locomotives weigh 82,500 lbs., are 32 ft. long, and are designed for speed of 2 miles per hour when towing locomotives, and higher speed when running light. 275 hp. motors are geared through heavy reduction to each axle. Three-phase 220 volt current is collected by contact plows. A two-speed windless is also provided.



Electric Towing Locomotive. Operates on Rack Railway at Two Miles per Hour When Towing and Higher Speed with Rack Gear Out When Running Light on Return. Two Speed Electric Windlass Is Provided.

The first lot of electric towing locomotives for hauling vessels through the locks of the Panama Canal are now being received at the Isthmus. In all forty of these "electric mules" are being built by the General Electric Company for this purpose. The machines weigh 82,500 lbs.; measure 32 ft. 2½ in. long by 8 ft. wide by 9 ft. 3 in., the greatest height over the cabs; have an available tractive effort as high as 47,500 lbs., and a windlass rope pull of 25,000 lbs., and four of them, two on each side, will ordinarily propel steamships through the locks. Sometimes six engines will be needed to handle extra large vessels; in every case two astern, acting as a brake on the ship's movements, will give direction to her course. No vessel will be allowed to enter the locks and go through on her own power.

The locomotive is built up of cast steel side and end frames, cross ties and bedplates. It is mounted on two axles with wheels in accordance with MCB standards. The entire frame is supported from journal boxes of the regular railway type by means of coiled springs. The sides and top of the body are enclosed by sheet iron covers which fit in place and are very easily removable. At each end are enclosed cabs so that the locomotive may be operated from either end.

The locomotive is propelled by means of a rack rail while towing and while going up or down the steep grades from one level to another at a speed of 2 m. p. hr. While running idle or on return tracks, the speed is changed to 5 m. p. hr. and the machine is propelled by the regular traction method, the rack pinion being entirely released. This change is effected by manually-operated clutches located in the gear mechanism in connection with a lever in each cab similar to a steam locomotive.

The locomotive is driven by two 75 h. p. totally enclosed motors of the mill type, one being direct connected through reduction gearing to each axle. Three phase, 25 cycle, 220 volt current is used and is collected by contact plows. The motor and traction gearing is mounted on a common baseplate, which in turn is mounted on a driving axle and spring suspended to the locomotive frame the same as in regular railway practice.

In the center of the locomotive is located a vertical windlass with drum, the capacity of which is 800 ft. of 1 in. steel hawser cable. The windlass with its driving motors and gearing is mounted on a solid baseplate and is likewise independent of the movement of the locomotive frame. The cable drum extends above the locomotive cover and has a floating guard placed around it to retain the cable while coiling loose.

The windlass cable is handled by the 20 h. p. motors, also totally enclosed and of the mill type. One is geared for a rope speed of 12 ft. per minute at a pull up to 25,000 lbs. at 2 ft. radius, and its function is to adjust the position of the ship for anchor or while being towed through the locks. The other motor is geared for a rope speed of 200 ft. per minute at 2 ft. radius, and its duty is to take up slack or pay out cable or wind in any part of the entire length of cable as may be required. The cable drum is driven through a friction device which can be set at any desired value from zero up to the full capacity of the motor.

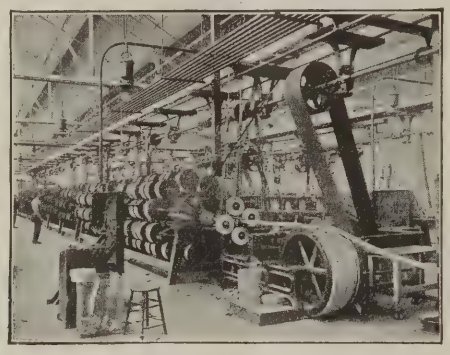
The traction motors as well as the windlass motors are controlled from either cab. In other words, the control equipment is duplicated. The two traction motors are operated by one master controller and contactors forward and reverse; while the windlass motors are operated by a reversible drum controller, and the clutch on the main vertical shaft by a solenoid. Later we will be able to give a more detailed description of the mechanical and electrical construction and performance of these machines.

How Telephone Cable Is Made

Merely stating that modern telephone cable consists of a group of copper wires, insulated by a wrapping of manila paper, twisted into pairs, and enclosed in a lead sheath, does not convey any idea of the complexity of the processes by which it is manufactured.

The materials of which cable is composed are copper wire, manila paper, tin and lead. These are furnished by the carload, the wire rolled in coils, the paper wound on spools, and the tin and lead in bars, known as "pigs." The wire is known as "soft drawn." It has been thoroughly annealed, i.e., softened and made flexible and drawn to the proper diameter, and differs from the so-called "hard drawn" wire used in outside line construction in its toughness and flexibility. The paper, which varies in thickness from 2½-1000ths to 14-1000ths of an inch, is especially made from the best manila rope fibre and is consequently very tough and durable. The metals are chemically pure tin and lead.

Machines Wrapping Paper Around Single Wires.



Machines Twisting Paper Covered Wires Into Cables.

Lead Pipe Machines Placing Sheath Around Cable.

The Insulating Process.

The first process that is actually carried on in the cable, rubber and insulating shops at Hawthorne is that of insulating the copper wire with its paper wrappings. The insulating machine consists of a number of revolving discs, an equal number of "capstans," or large pulleys, and the "take-up" reels. The bare wire is coiled loosely around large iron spindles. From there it passes over the pulleys at the top of the machine through the centre of the revolving discs. On the face of each disc a pad of the insulating paper is placed, and as the wire is pulled through the hole in the centre by the capstan beneath, the disc revolves, winding the paper around the wire in the form of an endless spiral. The insulated wire then passes over the capstan and is wound upon the take-up reel below.

Each disc is driven by an individual motor, and applies the paper to the wire at the rate of 2,400 to 3,000 "wraps" or turns a minute. Various colored papers are used, in order to make it easy to identify different sizes of wire or different pairs of wires in the finished cable.

Pairing the Wires.

The insulated lengths of wire are now ready to be twisted into pairs. Two of the take-up reels containing insulated wire of the same color are placed in spindles in the machine. A capstan at the top of the machine then draws the wires through a "yoke"—a revolving plate pierced by two holes through which the wires pass—twisting them together, and leads the twisted pair to another take-up reel. The machine is so adjusted that the length of the twist, that is, the number of twists to the foot, may be altered at will. Different lengths of twist are used for different "gauges" or sizes of wire.

Forming the Cable.

The twisted pairs of wires now go to the stranding machine to be formed into a cable. This machine consists of a number of revolving drums, which look like enormous skeleton spools. On the outer circumference of these drums are arranged the reels containing the various pairs. A large capstan draws the centre pair or pairs of wires straight through the centre of the machine; at the same time, the drums revolve, and the other pairs are unwound from the reels and are twisted in alternate directions around the centre. The finished "core," as the unsheathed cable is called, emerges from the machine, and is wound upon the capstan. The last layer of pairs is covered with a double wrapping of paper, to protect the core from the lead sheathing.

In order to cut the cable to the lengths desired by the customer, one of the centre pairs is carefully measured and the location of the end of this pair marked on the outside of the core. As it is often important to the customer that the lengths be absolutely correct, a check measurement is usually obtained, either by means of a recording device on the front of the standing machine, or by weighing the completed cable.

The Drying Process.

After leaving the stranding machine the entire length of cable core is carefully tested, to make sure that none of the wires are broken, and also that the paper insulation is perfect. The next process, that of drying, is very important, for the quality and efficiency of the cable depend to a large extent upon the care with which it is carried out.

The core is placed in gas ovens heated to 215 or 230 degrees Fahr., and is kept there for a period ranging from 15 to 48 hours, depending on the size and length of the core, the amount of insulation, and the character of service for which the finished cable is intended.

Sheathing the Core.

When the core has been thoroughly dried, it is put through the last manufacturing process, that of applying the lead sheath. The lead press, or sheathing machine, on which this operation is performed, is practically a machine for making lead pipe. It consists of a huge pot, or container for holding the metal, a core and die box, and a hydraulic press.

The container is filled with molten lead, to which an alloy of 3 per cent tin has been added. The bottom of the container opens into the top of the core and die box.

The "core" is a pipe through which the cable passes; the "die" is a mold surrounding the core. The cable to be covered passes into the back of the machine, through the core and the die. By this time the lead in the container is no longer liquid, but has cooled sufficiently to be in a plastic state. It would not do to apply the molten lead to the cable core, because the hot metal would burn the paper insulation off the wires.

The hydraulic press, working at an enormous pressure, forces the plastic lead through the die, or mold, and around the cable core, thus surrounding the paper covered wires with a continuous lead sheath of any length.

Final Testing.

As soon as the finished cable is cool enough to handle, it is given a final and very thorough electrical test. As it is essential that every cable contain at least as many perfect pairs of wires as are called for in the order, a few extra pairs are usually included in order to make up for any defective pairs that may be detected in the course of the final inspection.

Sealing the Ends.

When the cable has tested satisfactorily, the ends of the core are impregnated in paraffin and the sheath is sealed up so as to prevent possible entrance of moisture, after which the finished product is ready for shipment. Testing of the cable is one of the most important phases of its manufacture.

The processes just described are those for making telephone cable in general. There are, however, different types of cable, and their manufacturing processes vary. The so-called "silk and cotton cable," which is used largely on the telephone subscriber's premises, particularly for Inter-phone installations, differs from the standard in that the wrapping of the bare wire consists of silk and cotton in place of paper. The so-called "wool cable," which is used in telephone exchanges between the man-holes underground and telephone exchanges, has a wrapping of wool in place of the paper, the wool offering a greater resistance to moisture. Submarine cables carry both heavier insulation and heavier sheath.

The modern lead sheathing process places no limit on the length of a single cable. A cable recently made for the Western Union Telegraph Company consisted of two lengths of 37-pair cable, each of which was 5,500 feet—over a mile—long. The thickest cable made contains 600 pairs of No. 22 gauge wire, with an outside diameter of 2⅝ inches.

The cable factory is a one-story building, which at first glance seems insignificant when compared with the other and more massive buildings of the Hawthorne plant; but in reality this is the largest telephone cable plant in the world. Enormous weights of raw material are handled—2,000 tons of paper, 10,000 tons of copper, and 30,000 tons of lead being made into cable in a single year. The single-story building is the ideal cable factory, for with every process carried out on the same floor unnecessary lifting of the heavy material is avoided.

There is not a single lost motion as the manufacture progresses. At the east end of the building, cars containing raw material are unloaded and the sequence of the locations of the departments—insulating, twisting, stranding, baking and sheathing—is arranged so as to correspond with the order in which the cable evolves. At the other end of the plant the finished product is rolled into waiting cars. This cable factory is an excellent example of the successful application of the principles of scientific management.

School of Electricity

A Course of Training Prepared by the Pennsylvania Railroad for Its Employees

All back lessons of this course will be furnished at 5 cents each, which will also include, (1) *Railroad Electricians' Club,* (2) *A B C Car Lighting Course,* (3) *Practical Stunts, and* (4) *Question Box, as published that particular month.*

Lesson No. 12

Resusitation from Electric Shock

On account of railroads using electricity in so many different ways at the present time and to caution its employes against the possibility of injury by accidentally coming in contact with dangerous electric circuits and to give them instructions regarding the proper treatment of those who become injured from this source, this lesson has been prepared. This should be carefully studied and understood because it may be necessary on a moment's notice to take proper and immediate action in order to save the life of a fellow workman.

These precautions and the proper instructions are given before any pamphlets on power and lighting circuits or apparatus are issued in order to warn the employes of the possible dangers in the use of such equipment. This applies not only to those who have occasion to handle this apparatus in their daily work, but also to all employes who might be present or in the vicinity where a serious accident might occur, as they could be of assistance in properly treating the victim until the services of a physician could be obtained.

Injury is generally caused by direct contact with a line conductor, though with extremely high voltages, shock may result from coming too close to a live conductor. It is, therefore, obvious that the first precaution to be observed is:

Keep away from live conductors, as far as convenience will permit or safety may require.

Even telephone, telegraph and lighting circuits may be dangerous, as they may become crossed with high potential power circuits at some point out on the line. For this reason, employes whose regular duties do not demand their coming in contact with such wires should not do so intentionally.

The victim may be injured by shock, by burns, or by both, and in falling he may bruise his body or break some of his bones. Shock is caused by passage of current through the body, some part of which accidentally comes in contact with a live wire. This tends toward a more or less complete paralyzation of the nervous system, causing the heart and lungs to slow up and even cease to perform their functions. The degree of injury is largely dependent upon the conditions under which the shock was received. For in-

stance, if the electric circuit be completed by making contact with the body at the shoulder and hand of the same arm, current will pass through the arm and the shock will probably not be fatal, as it is possible for the vital organs to perform their functions without the aid of the arm. If, however, contact be made from one hand to the other, current will pass through the body near the heart and the shock may be sufficient to stop the action of the heart entirely and thus apparently cause death.

It should be remembered that in most electric circuits, one side of the circuit is generally connected to the ground, either intentionally or through a weak point in the insulation. For this reason a shock may be received by coming in contact with the other conductor, which would complete the circuit through the body to ground.

The victim may be burned by the flash from an arc or by the heating of the tissues of the body caused by the passage of current through them. In breaking contact between a live conductor and the victim, or between two live conductors, an arc may be drawn in such a manner as to produce a burn. While such a burn may be very painful, it is not, as a rule, very serious and may be readily treated. If current passes through the body, however, sufficient heat may be generated to burn the victim internally. Such a burn may be very serious, owing to its being inside the body, which makes its treatment difficult.

Promptness and Perseverance.

Acidental electric shock does not always kill, it may only stun the victim and stop his breathing for a while. The shock is not likely to be immediately fatal, because:

The live conductor may make only a brief and imperfect contact with the victim's body.

The skin, unless wet, offers high resistance to the current.

Prompt and intelligently directed efforts in removing the victim from contact with live conductors, and prompt, intelligently directed and continued efforts in restoring natural respiration, are necessary for successful results. While promptness is essential, undue haste is to be condemned. The failure of the victim to respond quickly to resuscitation should not cause discouragement; the effort should be continued because—

The body depends upon a continuous exchange of air, as shown by the fact that we must breathe in and out about fifteen times per minute.

If the body is not thus repeatedly supplied with air suffocation occurs.

Persons whose breathing has been stopped by electric shock have been restored after artificial respiration has been continued three hours or more.

Release of Victim from Contact with Live Conductor.

Extreme care must be exercised in releasing the victim from contact with a live conductor to avoid receiving a shock. A piece of dry non-conducting material, such as a piece of wood, a coat, piece of rope, rubber hose, or other material which you are sure is a nonconductor, may safely be used to remove the live conductor, or handle the victim while he is in contact with the live conductor. The use of conducting materials such as metal, moist or damp cloth, etc., is extremely dangerous. Many persons by their carelessness in such matters have been severely shocked or burned while trying to remove a fellow workman from a dangerous position.

Break contact between the victim and live conductor as quickly as possible. Open the nearest switch, cut the wires, or do any other thing that appears to be the quickest, safest and surest method of opening the circuit.

If the live conductor lays on the victim, or on the ground in a dangerous position, a dry coat, rope or other flexible dry non-conductor may safely be wrapped around the live conductor to pick it up, carry it to a place of safety, or to hold it in a safe position. The coat or whatever is used to hold the wire should be grasped several feet from the conductor to avoid receiving a shock.

If the victim is clutching a live wire, or if he is so entangled in live wires as to render the removal of either the victim or the live wire difficult or dangerous, either to him or to the rescuer, the live wire may be safely cut with an axe or cutting pliers having well insulated handles.

In cutting or handling a live conductor, or in handling the victim, be careful to see that the free end of the live conductor does not come in contact with either the victim, the rescuer or bystanders.

If the victim must be touched while in contact with a live conductor, the rescuer should cover his hands with rubber gloves, several thicknesses of dry cloth or paper, or stand on a dry board or other dry insulating surface. If practicable, he should use only one hand.

Send for a physician promptly and have him take charge of the patient upon arrival, but do not wait for him before starting to resuscitate the victim.

Resuscitation.

Resuscitation is the act of reviving, or attempting to revive, by manual methods, a victim of suspended animation simulating death, caused by electric shock, drowning, inhalation of gas, effects of cold, surgical or other shock, or the administration of an anesthetic.

If the victim can be made to breathe and to continue to breathe, the major part of resuscitation has been accomplished, and recovery is practically assured. Having freed the victim from contact with the live conductor, artificial respiration should be started immediately without waiting for a physician. Resuscitation may be delayed or discontinued only long enough to carry the victim to a convenient spot where fresh air is abundant, or to remove him to or from a train, and then only for the shortest possible time. Bystanders must not be permitted to collect closely about the victim; this prevents his getting fresh air.

If the accident happens on a train, the victim should be removed to the baggage car, or if it happens on the right-of-way between stations, a train should be stopped and the victim placed in the baggage car. The doors and ventilators should be opened to admit fresh air. Upon the arrival of the train at the first station where a physician is at hand, the care of the victim should be turned over to him and he should be furnished with whatever assistance is necessary to continue the artificial respiration.

The operator should quickly feel with his fingers and remove from the victim's mouth and throat any foreign substance such as tobacco, false teeth, etc.

He should not stop to loosen the victim's clothing at this time; every moment of delay is serious.

The victim should be laid on his belly, with arms extended forward, as shown in Fig. 1. His face should be turned to one side in such a manner that the nose and mouth will be free for breathing. An assistant should draw the victim's tongue forward.

The operator should kneel, straddling the victim's thighs, and facing his head. He should place the

palms of his hands on the muscles of the victim's back over the lower ribs. His thumbs should parallel the victim's back bone, and his fingers should spread over the lower ribs as shown in Fig. 1.

He should hold his arms straight and swing his body forward slowly, bringing his weight to bear gradually upon the victim as shown in Fig. 2. Pressure is thus applied over the lower ribs by the heels of his hands, compressing the lower part of the chest and the abdomen, and forcing the air out of the victim's lungs. This movement should take from two to three seconds, and pressure must be applied gradually and firmly—not violently. Excessive pressure may injure the internal organs and *sudden thrusts do not resemble natural respiration.*

First Position, Place Hands Over the Lower Ribs.

He should immediately swing backward to quickly remove the pressure. The hands should be kept in place, thus returning to the position shown in Fig. 1. Through their elasticity the chest walls expand and draw fresh air into the lungs.

After two seconds the double movement of compression and release should be repeated, making a complete respiration in four or five seconds or twelve to fifteen respirations per minute. If a watch or clock is not visible the operator should follow the natural rate of his own breathing, swinging his body forward with each exhalation, and backward with each inhalation. While doing this an assistant should loosen any tight clothing about the victim's neck, chest or waist.

Artificial respiration should be continued without interruption for at least three hours, or until natural breathing is restored. The movement should be continued for sometime after natural breathing has begun. In continuing the movement, the operator should be careful to keep his movements in step with the natural breathing of the victim. In stopping the movement the operator should see that the victim continues to breathe; if he stops, artificial respiration should be started again immediately.

The above method is known as the Schaeffer or Prone Pressure method.

Liquids should not be given by mouth until the victim is fully conscious. A physician only may administer stimulants; this should not be attempted by any other person.

Care of the Victim.

In handling the victim, burned parts should not be touched or irritated if possible, and in artificial respiration pressure should not be brought to bear upon burns.

During the period of restoring natural respiration, an assistant should keep the victim warm by applying a cover and by laying bottles or rubber bags filled with warm—NOT HOT—water beside the body.

If hot water is not available, rubbing the body or limbs with the hands or some rough fabric will produce the same result. Care should be taken not to rub the body at any point where the skin has been burned.

When natural respiration has been restored, any serious burns which the victim may have sustained should be cared for until the physician arrives.

Blisters must not be opened.

A raw or blistered surface should be protected from the air. If the clothing sticks, cut around it; do not peel it off. A dressing of soft material should be applied to the burn, and this, or the cloth adhering to the wound, should be saturated with a solution of baking soda (one teaspoonful to a pint of water) or the wound may be coated with a paste of flour and water.

Cover the dressing with cotton, gauze, lint, clean waste, clean handkerchiefs, or other soft clean cloth, and hold lightly in place by a bandage.

Then Gradually Press Down Until Full Weight is Exerted—Suddenly Release Pressure and Repeat Movement, Keeping Time with Your Own Breathing.

Similar coverings should be lightly bandaged over dry, charred burns, but without applying oil, acid or other liquid dressings.

After regaining consciousness, the victim should be watched carefully to see that he does not exert himself except in moderation. Violent exertion is liable to cause the breathing to stop, recovery from which is doubtful, although the same methods should be followed just as persistently as at first.

Conclusions.

While the above instructions may be readily comprehended, experience has shown that instructions, and even demonstrations on the part of others, are not sufficient in themselves to sharply fix the details of the operations in mind. Actual practice in the movements is necessary to insure a correct understanding of the ends desired, and the proper methods of accomplishing them. It is, therefore, necessary for those who desire to become proficient along this line, to go through the manipulations from time to time as both patient and operator. In emergencies, they will then be prepared to proceed without the necessity of reviewing printed instructions, thereby saving valuable time.

Problems

1—What is the first thing to be done with the victim in case he has received a dangerous electrical shock?

2—Describe fully several methods which may be used in removing a body from contact with a live wire without danger to the rescuer?

3—(*a*) On what do all such methods depend? (*b*) What articles should not be used to assist in removing a body?

4—How would you cut a conductor if it was laying on the victim or if he was entangled in it?

5—After removal of the body from the live conductor what are the first three things to be done?

6—What is resuscitation?

7—What should be the position of the patient when the work of resuscitation is begun?

8—What should be done while placing him in this position?

9—Why is the position of the head in this method so effective?

10—What should be the position of the operator's body at the start?

11—where and how should he place his hands?

12—What is the first movement which the operator should make?

13—In making this movement, should his arm be held rigid or otherwise?

14—How much time should be consumed in making the first movement?

15—Describe the second movement and how much time should it consume?

16—How much time should be consumed in the two movements, and why?

17—How long should artificial respiration be continued?

18—Who would be best qualified to say that artificial respiration may be discontinued?

19—What may be done by persons other than the operator to assist in the resuscitation?

20—Should any liquid stimulant be given the patient before breathing is established?

21—After the patient is fully conscious, how would you treat any burns which he may have sustained?

22—What is necessary in order that one may be ready to use this method at any time?

23—Do you think you could properly perform the "prone-pressure" method of resuscitation which is described in this pamphlet? If not, why?

The Railroad Electricians' Club

Meetings the 3rd Monday of Every Month, 8 P. M.—18th Floor Transportation Bldg., Harrison and Dearborn Sts., Chicago—Everybody Welcome—No Dues

Practical Battery Talks

Storage battery operation is becoming of greater and greater importance to the railroad electrician, as an increasingly large number of batteries are being employed in car lighting and signal service every year. In order that railroad men may be given the opportunity of hearing some of the best battery experts in the country on this big subject, we have arranged for a series of practical battery talks which should appeal to every railroad electrician engaged in battery work.

For our May meeting Mr. H. M. Beck, of the Electric Storage Battery Company, will address the club on the subject of "Operating Characteristics of the Lead Storage Battery in Railway Car Lighting and Signal Work." Mr. Beck is well known among railroad engineers and is one of the best experienced battery men in the country. This meeting will be held at the rooms of the Western Society of Engineers, 17th floor Monadnock Bldg., Tuesday, May 19th, instead of at the Transportation Bldg., which is the usual meeting place of the club. Note that it will be held Tuesday night at 8 p. m. instead of Monday night.

At the July meeting, Mr. H. H. Smith, Research Engineer, of the Edison Storage Battery Co., will address the club on the "Operating characteristics of the Edison Storage Battery in Railway Car Lighting and Signal Work." Mr. Smith has been connected with the Edison battery since its first development and we are very fortunate indeed in getting him to address the club on this subject.

Every battery man in the car lighting and signal departments who is located within 200 miles of Chicago ought to make a special effort to attend both of these meetings.

Both meetings will be held in the rooms of the Western Society of Engineers and numerous lantern slides will be shown.

First Lesson--Magnetism

1.—Give two methods of magnetizing a piece of steel.

No. 1. A piece of steel may be magnetized by stroking it lengthwise over one pole of a permanent magnet taking care to stroke it with the same end first in each case. If the south pole of the permanent magnet were being used this would turn each of the tiny molecules of iron around, which themselves are magnets, as the steel is passed over the pole, so that the north poles would point backward toward the south pole of the big magnet and all these little magnetic particles which are thus lined up pointing in the same direction will create a north and south pole in the piece of steel.

Another way would be to place this piece of steel in the center of a solenoid and pass direct current through the solenoid windings. There would be a magnetic field set up inside of the solenoid due to the current passing through its coils and this, if the current through the solenoid is strong enough, will create such a powerful magnetic flux through the bar of steel that it will retain a certain amount of the magnetism permanently.

2.—A steel ball is plated with copper and enclosed in a wooden box. Will it be attracted by a magnet brought near it?

No. 2. There seems to be no material which will insulate against the action of magnetic lines of force, therefore, no matter how many layers of metals, glass, rubber, etc., you place around a piece of iron, the magnetic lines will still act through this material and attract the steel ball inside just as if there were nothing covering it at all.

3.—If you were given a compass, how could you determine the north and south poles of a generator?

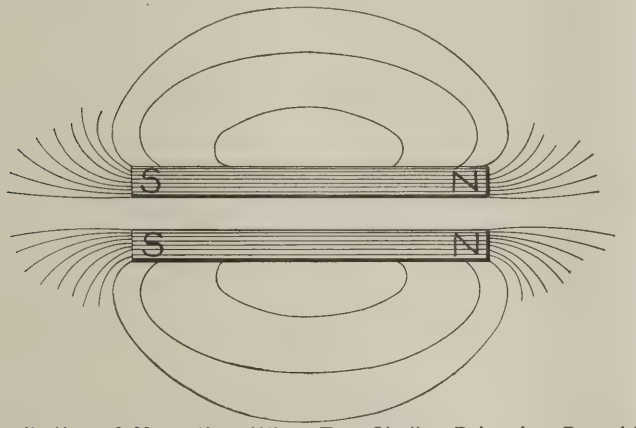
No. 3. Two north magnetic poles will repel each

other, while two unlike poles, a north and a south, will attract each other, therefore, when the compass is brought near a north pole of the generator the south pole of the compass will be attracted toward it, and the north pole of the compass repelled. When it is brought near the south pole of the generator the north pole of the compass will be attracted and the south pole of the compass repelled.

4.—Two bar bagnets are laid side by side with their N poles adjoining.
(*a*) Would they attract or repel each other?
(*b*) Make a sketch showing the distribution of the magnetic field about these magnets.

No. 4. (A) The north and south poles will repel each other, tending to separate the two bar magnets. With the ordinary bar magnet, however, this force will be rather weak and not sufficient to slide the magnets.

(B) The accompanying sketch shows the distribu-



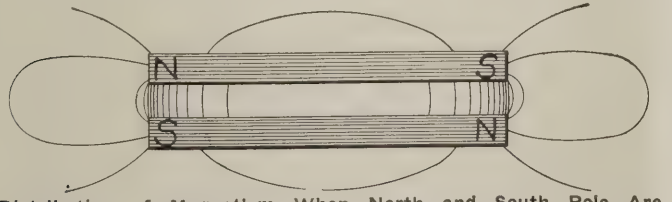
Distribution of Magnetism When Two Similar Poles Are Brought Together. Note the Lines Repel Each Other.

tion of the magnetic field created by these two magnets in this position.

5.—One of the magnets in question 4 is turned around, end for end.
(*a*) What difference does this make in the force between the two magnets?
(*b*) Make a sketch showing the distribution of the magnetic field.

No. 5. (A) The two magnets will now be strongly attracted to each other and the force may be sufficient to slide them together.

(B) The accompanying sketch shows the distribution of the magnetic lines and it should be noted that there are very few of them which pass out into space. The majority of the lines pass directly from

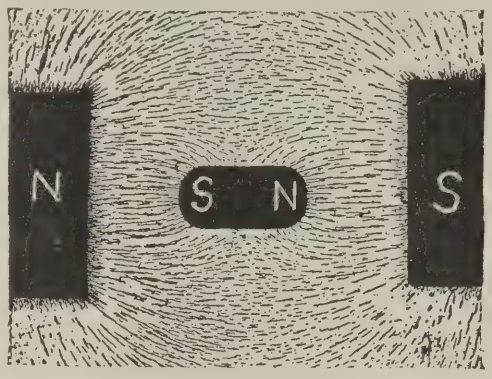


Distribution of Magnetism When North and South Pole Are Brought Together. Note the Magnetic Lines Go Direct from One Magnet to the Other.

the north pole of one bar, to the south pole of the other at the point of contact, and from the north pole of the other bar to the south pole of the first, to the contact at the opposite end. There will, of course, be a very slight amount of leakage, but this may be considered as practically a dead short circuit.

6.—The magnetic pole at the left side of Figure 6 (Jan., 1914, Lesson) is a north pole. Make a sketch showing the location and sign (whether positive or negative, north or south) of all other poles in the figure.

No. 6. A north pole will induce a south pole in the adjacent end of a piece of steel and a south pole will induce a north pole in the adjacent end, therefore, the poles will be as shown in the accompanying sketch.



Showing Polarity Induced in Piece of Soft Iron in a Magnetic Field.

7.—If a magnetic compass were placed between the poles of a horseshoe magnet, how would the compass needle behave?

No. 7. The point directly between the two poles of a horse shoe magnet is where the magnet field is strongest. Therefore, when the compass is placed directly between these poles, it will be held rigidly in position with its north pole pointing to the south pole of the magnet and its south pole pointing to the north pole of the magnet.

8.—(*a*) What shape should a magnet have to best retain its magnetism?
(*b*) How can two straight bar magnets be arranged together so that they will not lose their magnetism?

No. 8. (A) The horse shoe shape is the best for retaining magnetism since both poles are brought closely together and with the magnet keeper in place, (a small piece of iron placed across the poles), the magnetism will circulate strongly through the magnet and keeper and the strength of the magnetism will be retained for a long time.

(B) If two bar magnets are laid side by side, with the north pole of one to the south pole of the other, and if these magnets are of about the same strength, the magnetic flux of each of these magnets will circulate through them both very much as current would flow through two batteries short circuited through each other, and this will preserve the strength of the magnets.

9.—Why does a compass needle take up a definite position on its pivot? Explain fully.

No. 9. The compass needle takes up a definite position parallel to the direction of lines of force at that point, this is because lines of force act very much like rubber bands, they tend to shorten, and this action draws the needle from a crosswise position to one where it is parallel to the direction of the lines of force.

Problems for Next Month

Review Lesson on Ohms Law.

Prob. 1. What is ohms law, and why is it so important in electrical work?

Prob. 2. Give an easy rule for remembering this law.

Prob. 3. If a resistance of 1 ohm is connected across a 2-volt battery, the internal resistance of which is negligible, what current will flow?

Prob. 4. If another battery is connected in series with the first one, making 4 volts total, and the same resistance connected across these two cells, how much current will flow?

Prob. 5. If a 4-ohm resistance is connected across the 4-volt battery circuit, how many amperes will flow?

Prob. 6. What is meant by an ampere hour?

Prob. 7. If a storage battery discharges a 2-ampere current for 4 hours, how many ampere hours are taken from the battery?

Prob. 8. What is the difference between resistances being connected in series and in parallel?

Prob. 9. What is the joint resistance in a circuit containing 2 resistances of 1 ohm each in series?

Prob. 10. What is the joint resistance of a circuit containing two 1-ohm resistances in parallel?

Prob. 11. What is the joint resistance of a circuit containing 4 ohms in parallel with 2 ohms?

Prob. 12. What is the joint resistance of a circuit with 4 ohms in series with 2 ohms?

Prob. 13. If 4 ohms, 2 ohms and 1 ohm are all connected in parallel, what is the joint resistance of the combination?

Prob. 14. If a circuit made up of 200 ohms and 400 ohms in series is connected in parallel with a 300-ohm resistance, what is the joint resistance of the combination?

Prob. 15. What is the difference between a watt and an ampere?

Prob. 16. (*a*) How much current does a 60-volt, 25-watt lamp require when operated on a 60-volt circuit? (*b*) How much does a 30-volt 25-watt lamp require when operated on a 30-volt circuit?

Prob. 17. How much current will a 110-volt, 25-watt lamp consume when operated on a 110-volt circuit?

Prob. 18. Four 25-watt lamps and three 15-watt lamps of a 110-volt type are switched on a 110-volt circuit, what will be the total current consumed?

Prob. 19. (*a*) What is the resistance of a 25-watt, 30-volt car lighting lamp? (*b*) Of a 25-watt, 60-volt car lighting lamp?

Prob. 20. What current will flow through a 60-volt car lighting lamp when connected across a 34-volt axle generator as pilot lamp?

Prob. 21. Suppose a 30-volt, 25-watt lamp and 50-volt, 25-watt lamp are connected in series across a 60-volt circuit, how much current will flow and what is the total resistance?

Prob. 22. What is meant by the k. w. hour?

Prob. 23. If the rate of 8c per k. w. hour is charged, what will be the cost of ten 40-watt, 110-volt lamps on 110-volt circuit for six hours?

A. B. C. Car Lighting Course

Edited by Edward Wray

The first lesson of this course was published in our Feb., 1912, *issue. All back numbers covering over two years' work can be furnished, bound in heavy paper covers with special binding arrangement, so that future lessons can be added and preserved. This also includes all back lessons of the P. R. R. School of Electricity, the R. R. Electricians' Club, Prize Question Box, and Practical Stunts. Price* $1.00. (*See blank on page* 6.)

Lesson No. 28

Pyle National Headlight Type "E"

On many roads the electrical department has for years been operating electrical headlights, on other roads this department has just recently taken over the headlight proposition, and on the majority of the remaining roads electric headlights will soon be employed, so it is very proper that in this course of lessons, which is devoted to the interests of the railroad electrician, we should devote the next three or four lessons to the subject of electric headlights. The new type "E" Pyle National will be taken up this month, and the Moon, Remy, Schroeder and the Pyle type "C" at a later date.

Turbine.

The turbine wheel has a single row of buckets and is made of semi-cast steel. At the outer edge of the turbine wheel the buckets are securely dovetailed and electrically welded by a special reinforcing process between the wheel and a reinforcing rim, as shown in Fig. 153. Steam is admitted to the buckets from a single nozzle, but by means of two deflecting chambers the steam is re-directed after leaving the buckets so that it strikes the bucket three times before being admitted to the exhaust chamber.

The steam as received from the locomotive may be anything from 100 lbs. to full boiler pressure, and this, after passing through the governor valve, enters the nozzle chamber. Steam at high pressure has a certain amount of latent energy due to its high pressure, so when this steam enters the nozzle chamber

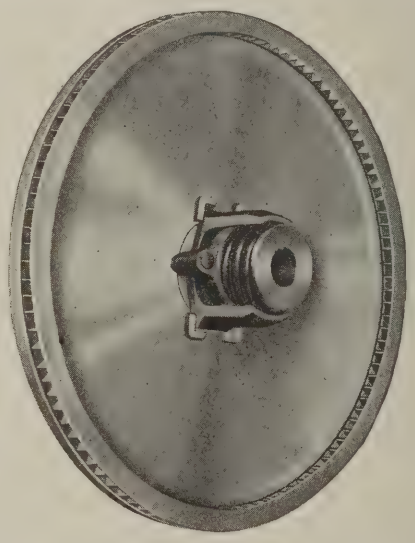


Fig. 153. Bucket Wheel of the Turbine Showing Location of Governor Weights and Spring.

it is allowed to expand within the nozzle so that the latent energy of the steam under pressure is transformed into velocity energy, causing the steam to leave the nozzle at the tremendous velocity of about 2,500 ft. per second, but at about atmospheric pressure. This blast of steam strikes the rotating buckets at an angle of about 20 deg. Since the turbine is traveling at a speed of 2,800 R. P. M. (47 revolutions per second), this, with a 12-in. bucket wheel, makes a bucket traveling speed of 150 ft. per second. But the steam traveling at 2,500 ft. per second strikes the revolving buckets with considerable force.

The surface of these buckets against which the steam strikes is curved so that in passing through the revolving bucket wheel the direction of motion of the steam is nearly reversed, and on leaving the buckets is going in a backward direction. Here, however, the

steam enters the first deflecting chamber, which reverses the direction of motion of the steam and directs it back into the bucket wheel, where it again strikes the buckets in a forward direction. Here the steam again strikes the curved surface of the buckets with considerable force and on leaving the bucket wheel is sent in a backward direction. But here it enters the last reversing chamber, which re-directs the steam back into the bucket wheel a third time and the steam again drives the buckets in a forward direction.

Each time the steam passes through the bucket wheel its velocity is reduced by about one-third and a corresponding amount of energy is given up in driving the turbine wheel, so that although the steam leaves the nozzle at the enormous speed of 2,500 ft. per second, this velocity has been reduced to probably 20 ft. per second by the time it leaves the bucket wheel for the last time and enters the exhaust chamber.

Governor.

A special balanced poppet type governor valve is supplied to keep the speed of the turbine constant regardless of steam pressure or amount of current generated by the dynamo. This valve is controlled by the weights mounted on the turbine wheel, as shown in Fig. 153, which fly out a certain distance when the speed comes up to normal, and through a lever at the back bear against the spring as shown. The higher the speed the more strongly will these weights fly out and compress the spring further, and if the speed falls off these weights will not be thrown outward quite so strongly and the pressure on the spring will be released somewhat.

This motion of the revolving governor weights, although slight, is transmitted by the levers No. 636 and No. 634 directly to the poppet balanced valve, either opening or closing it slightly, as required to supply just the right amount of steam. This has a throttling action so that the steam pressure inside the nozzle chamber will be maintained constant at about 100 lbs. regardless of how high the pressure in the supply line may run.

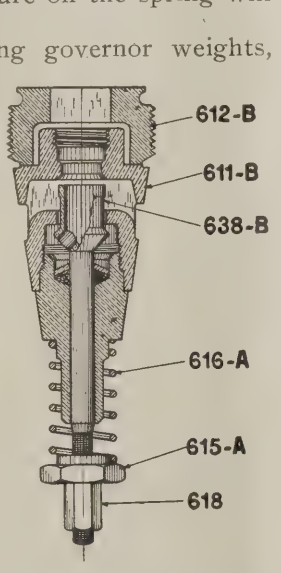


Fig. 154. Governor Valve.

Speed Adjustment.

Persons not familiar with valve regulation should not attempt to reduce the speed of the machine by loosening the governor screws, for very often the increased speed is caused by excessive valve travel.

When it is found necessary to change the speed, first note that valve 638-A is 1/16 in. from valve seat 612-A. If found to be more than 1/16 in., adjust the valve as described later; if found to be about 1/16 in., proceed as follows after taking speed reading: Turning the screws 617 to the right will increase, and to the left, decrease the speed of the turbine. Be sure and turn each screw a similar number of turns, or an equal fraction of a turn; ½ turn on each of the three screws will change the speed about 75 rev. per min.

It sometimes occurs that after shortening the valve travel the speed, when the arc is turned on, will be so much reduced that the electrician may fear the steam valve opening is insufficient to furnish the steam required to operate the arc. Unless the valve lift is less than 1/16 of an inch this is not the case. Instead, it will be found that prior to valve adjustment, some workman had reduced the governor spring tension in his attempt to control the speed (and thus prevent burning of electrodes), with the result that low speed followed after the correct valve adjustment had been made.

The electrician should become accustomed to the brilliancy of the cab lamps when the dynamo is running at proper speed with the arc lamp switched off. To the experienced man the brightness of the cab lights indicates whether or not the turbine is running over or under speed.

Following the adjustment of the governor valve, the machine should operate for a considerable time without adjustment. An inspection of the governor valve and occasional check on the speed of the equipment should be made at regular intervals. If it is found that the copper electrode fuses, the turbine speed should be taken, and if it is found to be excessive the governor valve lift should be examined to see that it is correct before re-adjusting the governor screws.

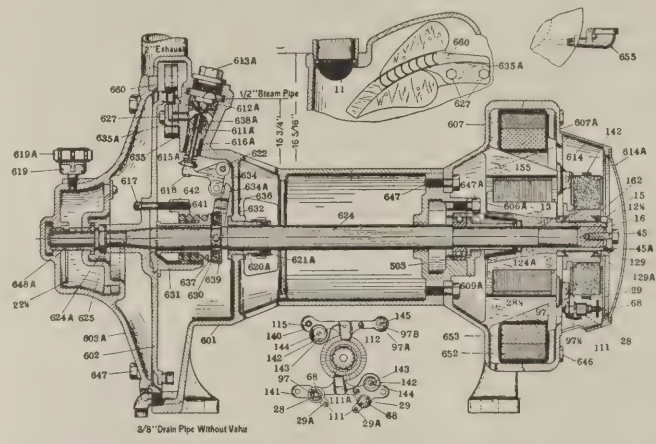


Fig. 155. Diagram of Section Through Turbine and Generator. Side View of Bucket Wheel and Nozzles Shown Above and End View of Commutator and Brush Rig Shown Below.

In service the travel of the valve or maximum opening increases due to wear, this in turn causes an increase in the speed of the machine. Therefore, if it is found that the increase in generating speed is because of a worn valve, the trouble should be corrected at this point and the valve set to the proper opening before adjusting the governor screws No. 617.

Setting the Valves.

The valve travel, as mentioned above, would be about 1/16 of an inch, and if on inspection it should be found to be, say, ⅛ of an inch, unscrew the valve seat No. 612-A, and with an ordinary ⅝-in. bolt remove the cage by screwing the bolt into thread of the cage; tap the under side of the bolt if the head of the cage sticks.

With the cage removed loosen the nuts, 615-A and 618, moving them lower toward the end of the stem by the amount it is desired to decrease the travel. In the above illustration it is desired to decrease the travel 1/16th of an inch. Therefore, the lock nut, 618, and adjusting nut, 615-A, must be located 1/16th of an in. nearer the end of the stem, when they again should be locked. With this done place the cage again in its position, taking care that one of the two ports in the side of the valve cage shall register with the ⅜-in. port in the turbine casting.

Screw the seat, 612-A, in place and again note the travel. Should it be greater than 1/16th inch another adjustment should be made.

Shaft and Bearings.

The turbine wheel is made with a tapered center and a similar taper on the shaft provides that the wheel can be securely pressed in place and locked by a nut and washer in its position on the shaft. In order to take the wheel from the shaft, the nut No. 624-A, Fig. 155, must first be removed, and then if the wheel is given a sharp blow with a hammer it will readily come off.

The turbine end of the shaft is carried on a plain sleeve bearing with a ring oiler and an oil chamber to furnish lubrication for a long period of time. This chamber is provided with an overflow, which drains off all excess condensation and maintains a permanent oil level; ½ pint of oil will fill the oil chamber and an additional quantity will simply run out of the overflow drain and be wasted. It will be well to add about 4 tablespoons full of oil to this bearing every trip. As explained, condensation collects in the bottom of the chamber and flows out through the drain pipe, so when it is desired to lay up an equipment for any length of time where there is danger of freezing, one pint of oil should be poured through the oil cup at the turbine end; this will overflow the oil chamber and force out all condensation water at the bottom.

The bearing at the generator end is a ball bearing and accordingly does not require as much oil as the plain bearing. An oil cup is provided which automatically drops sufficient oil on the bearing, and this should be kept nearly full at all times.

The outer race of the ball bearing is held securely in its recess on the end of the main casting by means of a retaining cap and bronze collar. The inner race is slip fitted on the shaft and held in place by a sleeve keyed to the shaft.

To change the bearing, remove the brush holders and armature lock screw No. 45, withdraw the armature, remove shaft pin No. 124-A, the 3 cap screws No. 647-A and the ball bearing cap No. 609-A. Then remove the turbine cover and pull the wheel with shaft out of the other end; the bearing will then be exposed and can be removed from the shaft easily.

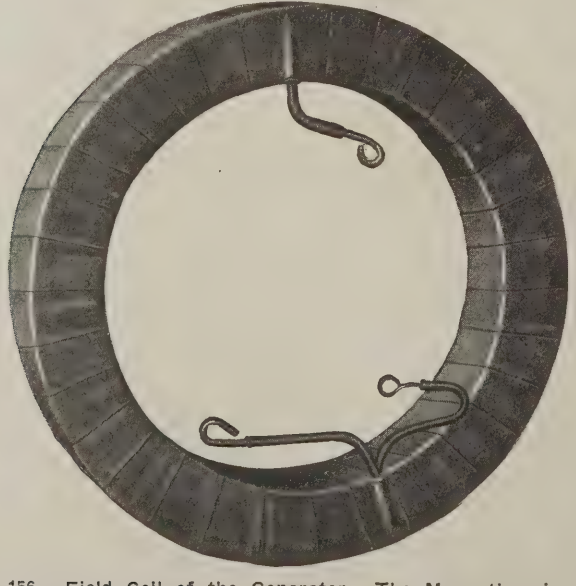


Fig. 156. Field Coil of the Generator. The Magnetism in Both Poles is Induced by This One Coil, Due to Special Construction of Pole Pieces.

The Dynamo.

The dynamo is of special construction, designed to meet the conditions of headlight service. It is a two-pole 30-volt machine with compound wound fields. The field windings are mounted on the dynamo in a rather unusual manner, as will be noted from studying Fig. 155. These are wound in circular form, as shown in Fig. 156, and placed as a single concentric ring around the armature. Current flowing through the shunt and series windings of the field coils will induce a magnetic field which, without considering the influence of the iron in the pole piece, would ordinarily be parallel to the armature shaft, and an armature revolved in such a field would generate no voltage whatever. The two pole pieces, however, are placed so that one of them receives its magnetism from the forward side of the field coil winding, and the other pole piece connects with the rear side of the field winding. The magnetic lines, then, which would under ordinary circumstances simply thread through the center of the ring winding of the field coil, will then be diverted so as to pass from the forward side of the

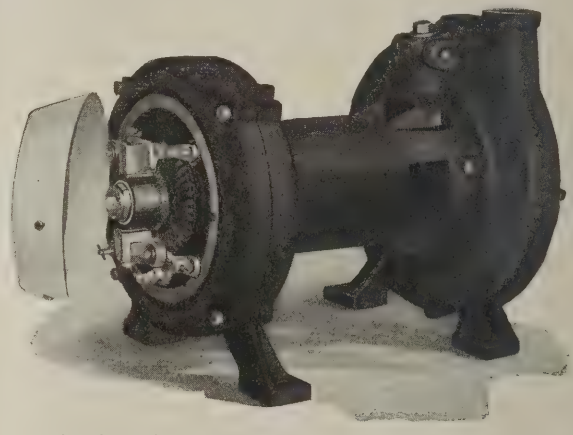


Fig. 157. Headlight with Generator Case Open.

ring, through the bottom field pole, then through the iron armature to the top pole piece, and thence to the rear of the field coil, and through the iron in the outer part of the headlight casing to the forward side of the coil, completing the magnetic circuit.

This magnetism in passing from one pole piece through the armature to the other pole, threads through all the conductors of the armature so that when the armature is revolved it will generate voltage as would an ordinary two-pole machine with two separate sets of field coils.

As the load on any simple shunt generator increases its voltage will decrease, due both to the increase in C. R. voltage drop through the armature, and also due to the armature reactions as explained in previous lessons of this course. The compound winding of this generator field, however, carries all of the current generated and as this increases it will cause the magnetic field of the dynamo to be strengthened and so make up for this ordinary decreasing voltage with load mentioned above, and keep the voltage delivered to the headlight and cab lights at a constant value, whether both headlight and cab lights are in service or only the cab lights.

The position of the brushes is fixed so as to commutate at the neutral point of the magnetic field and with all ordinary loads of the headlight and cab lamps, the shifting of the dynamo field, due to armature reactions which always occurs as the load comes on, will only be slight and should not cause undue sparking. The brushes, however, must be ground so as to

accurately fit the commutator in order to make good contact. This can best be accomplished by cutting a strip of sand-paper about the width of the brushes, (not emery paper, for this would leave emery dust on the brushes and commutator, which would wear the commutator rapidly in service); place the sand-paper strips between commutator and brush with the sandy side toward the brush and draw the sand-paper back

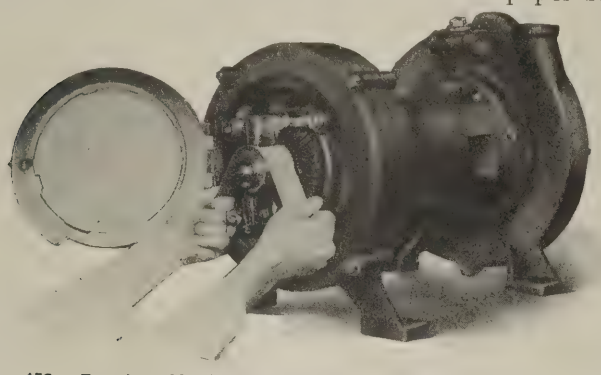


Fig. 158. Brushes Must Bear Evenly on Commutator.. Pull Strip of Sand-paper Back and Forth Under Brush.

and forth under the brush until it has been ground down to a proper bearing.

In service it will be found that the copper segments will wear away more rapidly than the mica, leaving the mica projecting above the surface of the commutator slightly. This, of course, prevents good contact of the brushes on the commutator and produces sparking. For the best results, the mica should be about 1-64 of an in. below the surface of all commutator segments. It should not be deeper than this, however, as this will furnish a groove for carbon and copper dust to collect which will short circuit the commutator and cause heating.

The mica can be trimmed down with the edge of a three-cornered file, thin hack saw blade, or any of the other methods described in our "Practical Stunts" column of past issues. After the mica has been reduced, the commutator should be cleaned up and all copper burrs removed with a strip of No. 0 sand-paper.

A spring is provided in the brush holder so as to give the brushes a firm bearing on the commutator. This spring is adjustable, but should not be tampered with except by an electrician thoroughly familiar with the equipment. In order to make the adjustment when the unit is undergoing repairs of a general nature, remove the screw, No. 144, and the adjuster, No. 143, may then be turned to the right or left as required. A flexible pigtail provides contact from the brush to the external circuit.

The Arc Lamp

The arc lamp is provided with one carbon and one copper electrode. It is well known that in any d. c. arc lamp the carbon connected to the positive side will wear away much faster than that connected to the negative side; this is because it gets very much hotter. It is also found that copper will serve as the negative electrode since the heat generated under ordinary circumstances will not be sufficient to melt the copper, and so in electric headlight work, where it is very important to keep the arc as nearly as possible to the focal center of the parabolic reflector, the copper electrode is used for the negative and carbon for the positive.

The carbon wears away more or less rapidly as the greatest amount of heating of the arc takes place at the positive electrode and this is automatically fed downward as required, but the copper electrode shows very little wear so the position of the arc remains fixed at the focal center. Where the current is not excessive, the copper electrode will burn away so slowly that it will require readjustment only once a month to bring the arc back to the focal center of the reflector. The experienced man by looking at the beam can tell whether the copper electrode needs readjustment; raising the copper electrode will lower the beam, and lowering it, raise the beam.

The carbon electrode is fed downward and also lifted away from the copper electrode, in striking the arc, by means of a series magnet mechanism with clutch on the carbon. When the arc breaks the carbon falls down on the copper electrode, allowing heavy current to flow. But this current flowing through the series winding of the solenoid pulls downward on its plunger and through a series of levers lifts the carbon sufficiently to strike the arc.

In trimming the lamp it will be found much better to remove the carbon clamp from the slide 100, Fig. 160. If it is necessary to remove the lamp and reflector from the headlight, remove the top guide and unscrew the wing nut at the top of the upper arm of the lamp frame, the guide, carbon and holder may then be taken from the lamp.

In disconnecting the lead wires from their binding posts, always be sure to bend one end back so as to identify it and so that the lamp may be connected up again properly.

The tension spring, 93 in Fig. 160, attached to the middle lever is simply for the purpose of counter-

Fig. 159. Rear View of Lamp Showing Operating Magnet, Levers and Clutch.

balancing the weight of the levers and of the iron plunger of the solenoid, so that the clutch may release the carbon. The tension on this spring should be adjusted when there is no current passing through the lamp and should be just sufficient to bring the bottom lever up against the top stop on the lamp supporting frame.

If the tension on this spring is too loose, the light will flash and go out, especially when the locomotive is at rest, since the weight of the plunger and levers is not properly balanced. If there is too much tension

put on this spring, the solenoid may not be able to separate the carbons sufficiently to produce good light; this will cause a heavy current to be generated and pass through the solenoid, causing it to heat and destroy the insulation in both solenoid and dynamo.

When the arc lamp is not burning the carbon must pass freely through the clutch and rest centrally upon the point of the copper electrode. When starting if the carbon and copper electrode are separated, even by a small fraction of an inch, the light will not burn, although the dynamo may be running at full speed. This may be caused by a small globule of fused matter on the point of the carbon, by dust or a cinder, or by the fact that the carbon sticks in the clutch and guides.

Most of the troubles with electric headlights are directly due to improper adjustment of the lamp and

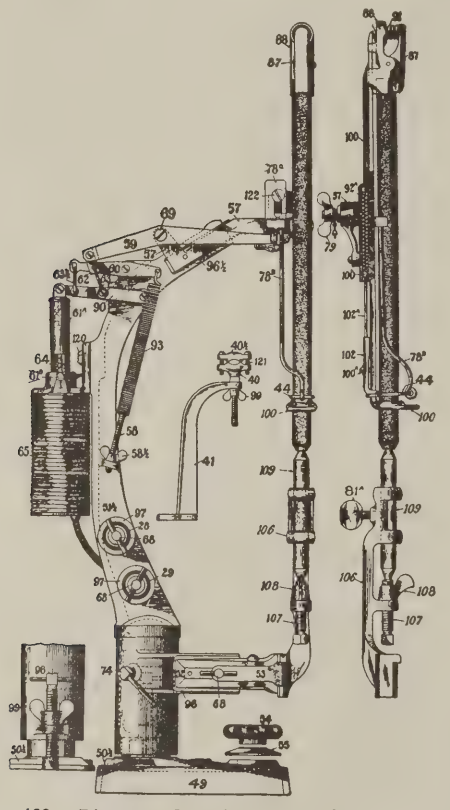


Fig. 160. Diagram Showing Side View of Lamp.

if ordinary care is taken in making the adjustments noted below, much of this trouble will be avoided.

Lamp Adjustment

Solenoid yoke, 90, may travel too far from the upper of the two small lugs on the lamp frame before the carbon and copper electrode are sufficiently separated to make the proper arc. When clutch, 44, begins to raise the carbon the upper edge of solenoid yoke, 90, should not be more than ⅛ of an in. below top stop lug. If the yoke, 90, travels too far from the top stop lug, it is an indication that clutch, 44, has become worn, and same should be replaced with a new clutch. The proper position for the lamp levers when solenoid yoke, 90, is up against top stop lug should be such that the clutch weight, 78-A, rests on the forward end of lever 59. Clutch rod should then be adjusted so clutch, 44, rests horizontal.

If the clutch rod, 78-B, is too short the carbon will stick in clutch, 44, causing lamp to go out. Clutch rod, 78-B, should be of sufficient length to hold clutch 44 at right angles to upper carbon holder slide 100.

If the light burns green the dynamo may be running too fast in which case the speed should be reduced, as explained in first part of the lesson. Until this condition can be properly attended to at the terminal the steam supply to the turbine should be throttled at the globe valve in the cab.

Another reason for the light burning green may be in the lead wires from the dynamo to lamp having been connected up wrong. To prevent this happening, each of the two ends of the positive wire should be doubled over so as to make impossible their connection to the wrong binding post. The ends of the negative wire should be left plain for entering the small hole of the binding post 29.

To Focus Lamp

1. Adjust back of reflector so front edge will be parallel with front edge of case.
2. Adjust lamp to have point of copper electrode as near center of reflector as possible.
3. Have carbon in center of chimney hole in reflector.
4. Have locomotive on straight track and move lamp until you get best results of the light on the track. The light should be reflected in parallel rays.

To lower light on track, raise lamp. To raise light on track, lower lamp.

If your light throws any shadows it is not focused properly.

If light is focused properly and does not then strike center of track do not change focus, but shift entire case on base-board.

Point of copper electrode should be about one inch above top of holder, 106. If it is higher than this, there will be too much heat on clutch, 44.

The following is the approximate focal point of various size reflectors:

16	in. x	8	in.	2⅜ in.
17½	in. x	10½	in.	1⅝ in.
18	in. x	8¾	in.	2 3/16 in.
18	in. x	9	in.	2¼ in.
18	in. x	12	in.	1¾ in.
23	in. x	14	in.	2⅛ in.

Athletics as an Aid to Efficiency.

The American Pulley Company is to be congratulated on the form displayed by its employes on their first annual field day, held not long ago on the company's big athletic grounds. The "American" boys showed there that muscles developed by hard work are as capable of prowess in the various departments of field sports as sinews trained by expert professional coaches.

The record made by the "Americans" compared more than favorably with those of college athletes and other amateurs. But that is not all. The company has a greater claim to congratulation in its progressiveness and farsightedness in providing such ample facilities for, and promoting interest in, athletics among its employes. Other large plants would do well to take to heart the motto which the officers of the American Pulley Company have perhaps unconsciously adopted, "All work and no play makes Jack a dull boy." One thing is certain, "American" Steel Split Pulleys have not suffered in quality nor has their number per day diminished since field sports were introduced at the company's Philadelphia plant. Every day during the noon hour the large athletic field owned by the company is used by the employes. The company has an organized baseball team for the summer and soccer and basketball in the winter. Tennis is the favorite of the office corps.

Prize Question Box

This "Question Box" is open to every electrical man in the Mechanical, Signal and Telegraph, as well as Car Lighting Departments. We feel that this can be made a mighty valuable thing, so as a special inducement to the boys to boom it, we offer prizes for the best questions asked, as follows:

First prize .....$1.00 *in cash*
Second prize .....9 *months' subscription*
Third prize .....6 *months' subscription*

There are some questions that are of a general nature, which should have comments of prominent men of experience. These will be published under "Questions Before the House," and we hope that prominent railroad men and manufacturers will discuss these questions. All answers published will be paid for at $1.00 *each.*

Questions Before the House

Field Fuse Trouble.

No. 3. On Bliss equipments I find that the shunt fuse will almost invariably blow if the automatic switch does not close or if there is an open in the battery circuit. But on the Moskowitz type of equipment I quite often find that the automatic switch does not close and yet the shunt fuse does not blow as it would in a Bliss equipment. Will you try to furnish an explanation?—S. W. Everett, Santa Fe.

Current in Moskowitz System.

No. 4. Why does the current run up on a Moskowitz equipment as the speed of the train increases? That is, if the dynamo is set for 30 amperes when the train is running at 30 miles an hour and when the speed of the train increases to 50 miles per hour, you will find that the output of the machine has raised almost double, to perhaps 45 or 50 amperes.—A. E. Voigt.—Santa Fe.

Water for Flushing Batteries.

No. 6. Why do battery manufacturing companies prescribe that only absolutely pure distilled water must be used for flushing the cells, when if pressed they will all admit that it is permissible to use Lake Michigan water? Is this water of equal purity with distilled water?—J. L. Ohmans, Elec. Fore., C. & W. I. Ry.

System of Handling Repairs to Axle Equipment.

No. 7. What is the best method of handling repairs to axle devices? That is, is it better to make repairs on each device enroute or at terminals as soon as the trouble develops or, by having a few spare equipments, simply replace the complete board or the complete generator which is giving trouble and make the necessary repairs in the shop?—L. S. Billau.

Belt Fasteners.

Can any reader advise if he has tried out the Walker belt fastener in cold weather?

In Canada we have tried out the Crescent and Alligator fasteners without success, the belt cracking after about 3,000 miles, due to being stiff through freezing. We are now altering our truck suspensions to permit using the Walker fasteners on all cars, this type of fastener requiring more clearance than the Crescent. E. S. Mac Nab, Can. Pac. Ry.

Axle Generator Suspension.

Does a rigid axle generator suspension possess any advantage over that using spring tension; and, if so, under what conditions?—L. S. Billau, B. & O. Ry.

Smooth Forged vs. Rough-Turned Axles.

Is any railroad obtaining successful results in the application of axle pulleys to smooth forged axles in place of rough turned axles?—L. S. Billau, B. & O. Ry.

Ampere Hour Meters in Car Lighting Service.

What attention has it been found necessary to give ampere hour meters in car lighting service to maintain them properly? How frequently should they be removed from cars and taken into shop for thorough overhauling?—L. S. Billau, B. & O. Ry.

Weak Cells in a Battery.

In testing out batteries which are in a partly discharged condition, it happens that one or more cells show a reversed polarity when the test is made with load on the batteries. After disconnecting the reversed cells, however, they show a weak voltage in the right direction. Are the cells so affected actually reversed, or is the internal resistance of the cells so high that current goes through the voltmeter in the wrong direction when the cells are in circuit with the set?—W. M. Wiggins, Pullman Co., St. Louis.

Voltage of Edison Batteries.

Is the voltage of the Edison battery affected by standing idle for a few days in extremely cold weather?—G. B.

Reversal of Battery Cells.

Why will one or more cells in a battery become reversed without any apparent cause for so doing?—Z. Humphrey, Santa Fe, San Bernardino, Calif.

Ground on Type "K" Relay.

What effect will a ground on a type K relay have on the operation of the U. S. L. equipment?—Frank M. Burke, Pullman Co., Jersey City.

Excessive Heating of 110-60 Volt Train Lighting Generators.

The turbine driven generators in our head lighting service were changed from 110 volt to 60 volt operation a few years ago. When this was done an extra resistance unit was placed in the shunt field of the generator and a shunt of proper resistance connected across the compound field. Some of the machines give serious trouble due to overheating and the men report that this seems to be caused by the shunt on the series field.

It is possible to operate the generator without this series field shunt when lamps alone are connected as a load on the generator. But when the batteries are connected, regardless of their conditions of charge, the voltage of the machine is very difficult to control without the shunt on the compound field.

Why should these generators heat excessively, and why should it be possible to control the voltage without the shunt when lamps alone are on the generator, but be impossible to do so when batteries, with or without lamp load, are connected?—C. R. Gilman, Chief Elec., C., M. & St. P. Ry., Milwaukee, Wis.

First Prize

Generator Won't Motor.

Ques. What is the first thing to be done when the generator refuses to motor in the yard? J. G. Koppel.

Ans. This indicates that there is trouble either with the generator armature circuit, or the field circuit, or both. You can quickly determine whether the trouble is with the armature or the field by opening a connection in the field circuit with the automatic switch closed. If you get a fat spark the field connection is O. K., but if there is no spark the generator fields are open. If the trouble is in the generator armature circuit you will

get no spark on opening the automatic switch, provided the connection of the field circuit mentioned above is left open.

Follow the connections on the board out carefully to see that the fuses are O. K. and that there are no loose connections. Take a look also at the generator field rheostat if the trouble is in the field circuit; then go below and look over the generator leads carefully to see that none of them are broken; then open the generator and inspect the brushes to make sure they make good contact on the armature. If the trouble is in the generator fields, test the generator fields out with a voltmeter; the coil across which you get a voltage indication will indicate an open circuit.

Second Prize

Break Beam Position.

Should the truck and generator suspension be designed so as to make the lower run of the car lighting belt pass under the brake beam or over it?—Edward Wray.

To the Editor:—The belt should always pass under the brake beam, as it is less liable to damage the fastener should it foul the beam, for this reason less clearance is required when belt is below the beam.—E. S. MacNab, Can. Pac. Ry.

Third Prize

Motoring Generator.

Ques. Suppose the tension is not released on a car lighting generator belt, but the main fuse is removed and the automatic switch closed. If the main fuse is flashed across its terminals so as to connect the generator to battery, would this reverse the fields or otherwise affect the machine aside from burning the commutator or brushes?

Ans. This should not burn the commutator or brushes for the current cannot exceed the rating of the main fuse, which should be no larger than the full load capacity of the machine.

As soon as the automatic switch is closed the shunt field of the generator and all voltage coils will be energized so when the main fuse is flashed across its terminals, allowing full rated current to flow through the armature, this can have no injurious effect on the generator as it is simply reproducing normal conditions of operation as far as the magnetism in the armature and fields is concerned. The armature current flowing through the armature in a reverse direction, however, will cause the armature reactions to be developed in the opposite direction from normal operation; but this will not be sufficient to seriously affect the machine. On machines where an interpole is provided, the armature current flowing through the interpole entirely neutralizes the effect of armature reaction.

Bill Miller's Pardon

Or the Trials and Tribulations of a Car Lighting Foreman

William J. Miller ('course the name is fictitious),
Is a man who was never at all superstitious;
But a dream which he had is a direct intimation
Of his faith in the doctrine of predestination.
Now the said William Miller, please bear you in mind,
Is a Car Lighting Foreman, who, like all his kind,
Has trials and troubles too many to state—
And, with this introduction, his dream I'll relate.
A spirit appeared at his bedside one night,
Decked out in a garment of pure spotless white,
And thus addressed Bill: "To me has been given
Command from the recording Angel in Heaven,
To ascertain why your name should appear
On the great Book of Life, as the reason's not clear,
The profanity record has been kept for ages,
And nothing like yours appears on its pages.
Therefore, 'tis decided, unless you can show
Just cause for defense, to send you below,
Where the fire is unquenched, and those who have never
Repented are roasted forever and ever."
On hearing the latter Bill tried hard to smile,
And invited the spirit to tarry a while.
"If I fail to make my defense in full measure,"
He said, "I'll be sentenced with the greatest of pleasure.
Please remain here tomorrow, accompany me
And report to headquarters whatever you see."
The spirit agreed, I am happy to say,
And took note of what happened the following day.
First, a conceited young clerk with expression Satanic
Brought a bundle of letters from the Master Mechanic,
And here a few, extracts I'll gave as example,
Of a bunch that the spirit took away for a sample.
"Please note that the Superintendent complains,
We are having poor lights on our passenger trains."
"Please let me know what excuse you can make,
Why so many adjusting space bars 'brake'."
"Lighting failures, last year for the month were but seven,
I regret for the same time this year there's eleven."
"You must take up the matter and ascertain why
We used so much oil in the month of July."
You are surely aware that a half-pint to use
Of machine oil per car is simply abuse.
I believe 'twould be wise (at least we can try it),
To give the men feathers with which to apply it."
"The President's special is leaving today
At 10:25, there must be no delay."
But, alas for the plans of mice and men;
The telephone rang at a quarter to ten,
And the station inspector announced with a drawl,
"The President's car has no lights at all."
A battery man appeared at the door,
"There's seven dead cells in the 864."
Then came a road inspector swelled up like a toad,
You'd think from his looks he would surely explode,
And asked loud in the name of the evil one:
"Why hain't the work on 490 been done?"
Bill Miller, he then made an angry retort,
While the spirit examined the inspection report
Of this road inspector, and this was the news—
Renew the switch carbons and test the main fuse,
The belt is a slipping, one battery cell leaks,
The rocker shaft bushing's so dry that it squeaks.
The lamps are flickering, clean carbons well,
The pulley end bearing runs hotter than—it should.
The tension rod bushings are worn on both sides,
The axle pulley sounds loose when she rides.
The solenoid sticks on the upward stroke,
Examine and see if the plunger ain't broke.
Flush the batteries and test them for grounds,
Shorten the belt and turn it around.
The machine's out of line an inch or more,
And fix the ketch on the switch locker door.
I think from the way she's been throwing fire,
That somebody's set her output higher.
Before the good spirit got through taking notes
From the book containing the work reports,
From the Chief Engineer came a message which read,
"The Saint Louis Special's turbine is dead.
Have men at the station to meet the train;
Why you put this one on 41, please explain."
Then a batteryman said that when crossing a switch
They had upset a truckload of cells in the ditch.
The spirit departed, and on the same night
Returned with a crown, and in greatest delight
Presented to Bill's most astonished vision
A text of the Recording Angel's decision,
And a list of the great hero saints all revealed,
With William J. Miller's name leading the field.

Practical Stunts

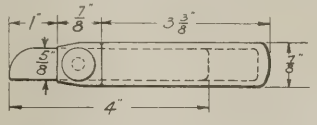
We Pay a Dollar Apiece for Practical Stunts—Send in Your Ideas

Method of Cutting Belts.

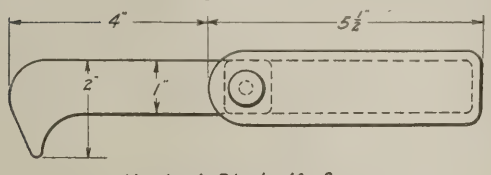
Editor's Note—We recently received a Practical Stunt from one of our readers suggesting that a heavy bladed cleaver, very similar to that used by butchers, be used for cutting belts. This communication was handed to a belt man and his comments are given herewith:

To the Editor:—

In reply to yours of the 14th, we are inclined to think that the man who put in this suggestion has missed his vocation. He should have been a butcher instead of a belt man. I would personally like to see him cut a few with a cleaver, such as he has drawn for you.



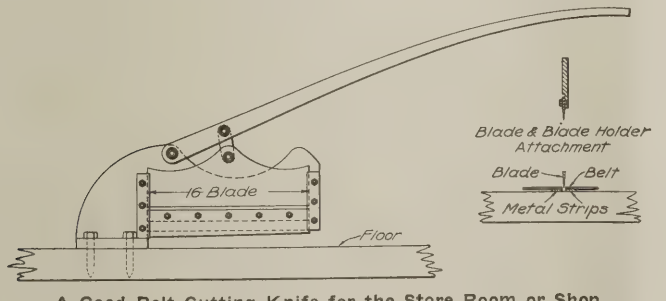
Straight Blade Knife



Hooked Blade Knife

Various Types of Knives Used for Cutting Belt.

There are so many ways to cut belts that it is really a joke to us to watch it. We have seen men cut belts with anything from a hacksaw blade to a saw. You will probably remember the writer showed you a knife when you were last in Philadelphia, that we have had specially made for car lighting purposes. In Fig. 1 of the sketch we are herewith enclosing, you will note that the blade on the first knife is hooked. This kind of a knife is the



A Good Belt Cutting Knife for the Store Room or Shop.

one that the writer found used a great deal by the men in cutting rubber belts. After making the marker across the belt, they would pick the belt up in their hands and see-saw it across until they cut it through. Sometimes they would get it straight, but more often it would be high on one point and low on the other. It will be impossible for a man to make a straight cut with one of those hooked knives in any kind of belting.

Now, in the straight knife, as shown in Fig. 1, allow about an inch of the blade to extend past the handle. See that the belt is on a flat surface and place a square firmly against the edge of the belt and pull the knife across the belt three or four times. In this manner a man is able to get a perfectly clean cut, whatever kind of belt is used.

With the idea of a cleaver being used, it would, of course, necessitate the same being pounded by a hammer to part the two ends of the belt. A cleaver would be all right, if it were kept sharpened constantly, but a steel cleaver being pounded would eventually break—and, of course, make it useless. A tool of this kind, if it were not kept sharpened, would make a ragged cut, and we are afraid that a man cutting many belts in such a method would soon lose his patience and go back to the old idea of a knife.

In Fig. 2 we have shown a belt cutting machine. This machine could be bolted right to the floor, and a man would cut a belt through with one pull down on the handle. You will note that this blade is wider at one end than it is at the other. This is made for the purpose of starting the cut at one end and as the handle is pulled down, cut it clean through to the other side without the force being put upon the top of the belt and from one edge to the other, which would not make a clean cut. We think you will see the reason for our advancing the idea of one end of the blade being deeper than the other, and feel that if a number of the storekeepers would adopt this plan of cutting the belts right in the storeroom, it would save a lot of waste. We have seen a number of these machines in use on the railroads and they all seem to like them. Of course, this would not be practical for the man who cuts the belts on the outside, he being obliged in that case to use a knife.

One of the biggest losses in car lighting belting today is the bad squaring up and cutting the belts at the very beginning. If a belt is once cut crooked, it will never straighten itself.

W. E. Fawcett, Main Belting Co.

Axle Dynamo Clearance.

In certain cases it develops that the dynamo is too low to give proper clearance above the height of rail and where the belt passes over brake beam, it allows the belt to come too close to the brake beam. This can be remedied by raising the side irons of the generator suspension and placing shims, 3/8 in., 1/2 in., or 3/4 in. thick, as required, between the side iron and the top of the truck sill. These shims are then bolted securely in place by means of the heavy side iron bolt strap which passes through the truck sill.

H. G. Meyers, Santa Fe.

Petrolyte Tank.

In heating the petrolyte tank for sealing battery covers there is always a great danger that the petrolyte may catch fire from the gas flame. If this ever does happen the petrolyte burns fiercely and makes an almost unquenchable fire. There is another feature, however, in the fact that where it is heated from the gas flame the bottom of the tank cakes badly and this both wastes petrolyte and spoils the tank.

We have recently adopted the steam coil method of heating the petrolyte tank and are getting very satisfactory results. The steam coil was made by knocking one flange off an old armature pulley and bending a 1/2 in. pipe around the pulley. By leaving the steam cock open slightly the steam coil will keep the petrolyte at a uniform temperature and there will be no caking whatever.—Bert Pachaly, Rock Island.

Sliding Cover for Train Line Receptable.

On Pullman cars equipped with axle devices the car is often operated for months without the train connector ever being inserted in the receptacle. In a short time the collection of dust and cinders in the receptacle is sufficient to cause serious trouble, if not making it impossible to insert the connector.

On cars recently built I have had provision made for a sliding cover for the receptacles, as shown in the accompanying sketch. This does not add any complication to the equipment and materially improves the service, as the receptacles on cars so equipped remain clean and ready for service all the time.—H. H. Bierman, B. & O. Ry.

An Adjustable Pinion Puller.

This is a tool that has proved its usefulness, yet is easily constructed in most any shop. Take a steel bar, preferably of rectangular form, and in the center drill a tap for the pushing screw that bears against the end of the shaft, and then make two arms with hooks on one end and bosses on the other; in the bosses are holes slightly larger than the rectangular bar, so that the arms may be slid up and down the bar to suit the diameter of the pinion or pulley that is to be removed. Set screws may be placed in the bosses to hold the arms in any position desired. J. R. Pratt.

Charging One Cell in a Battery.

It very often becomes necessary to charge one cell of a battery separately from the others, but in some cases it is not convenient to charge this cell from the charging plant. But even if this is done, there is a great waste of energy in the water box or other resistances placed in series with the cell to cut the current down to normal value.

A simple way of doing this is to disconnect the terminals of that particular cell from the rest of the battery and attach leads long enough to reach any of the other cells in the battery. By connecting these leads to the outside terminals of a twin cell tank, positive to positive and negative to negative(current will be supplied by these two cells in series to charge the low cell. This would furnish about 4 volts at the terminals of the low cell, which would be entirely too high, so a resistance of sufficient current capacity such as a piece of iron wire should be inserted to keep the current down to normal.

In charging the low battery we, of course, discharge the other two cells, so the connections should be changed during the charge, shifting from tray to tray so that no particular pair of cells will be overworked in bringing up the low cell.

Walter Brightman.

Editor's Note.

There is always some good reason for one cell of a battery being very much lower in voltage and capacity than other cells in the battery. This is usually found to be due to short circuits or impurities in the electrolyte and, as explained in answers to previous questions in this department, the cause of the trouble should be removed first and then that cell charged as you suggest.

Portable Lamp.

A portable lamp which is very convenient for use on lathes or other machine tools, or around an engine, can be made by mounting an ordinary socket upon a magnet spool enclosed in an iron casing, connecting the lamp and winding of the magnet in series. The magnet spool will stick to any iron frame or other object, and so hold the lamp in any desired place. Where the portable is to be used on low voltage circuits, such as in car lighting, the wire of the magnet spool must be large enough so as to reduce the voltage on the lamp to any appreciable extent.—M. F. Hand, Topeka, Kans.

Steam Tray for Removing Covers.

The accompanying illustration shows a new device recently applied in our shops for removing rubber covers from battery tanks. When the battery is first received, four double compartment tanks are placed on a truck and covered with a sheet iron inverted tray about 4 in. deep, as shown in the illustration. Steam is turned on through the center of this cover and

Steam Cover for Softening Rubber Battery Jar Covers Which Are to be Removed.

passes over the tops of the battery jars, warming them thoroughly and softening the rubber covers.

After about 2 minutes warming, the cover is lifted and the petrolyte sealing compound is softened and the covers are jerked out with a hook, coming out of the tanks very much like a dishrag. These, however, are easily straightened on allowing them to cool. Since installing this apparatus we have not broken a single battery cover in removing them from the tanks.—Bert Pachaly, Rock Island.

Repairing Coils.

The lead wires to coils usually break right at the coil. If the broken end projects as much as ⅛ of an inch it can be neatly repaired in the following way:

Scrape the projecting end clean and press a piece of sheet mica drilled to proper size, over the projecting end of the broken wire. The mica thus forms a washer which prevents the solder from going down into the coil. Then take 2 pieces of wire the same size as that broken and clean them for about 2 in., one wire is then wrapped carefully around the other for about three turns, or as much as the projecting end will carry; take the little pig tail off the wire and work it carefully over the end of the broken lead and solder it fast. Then cut away the mica washer and tape the joint. J. R. Pratt.

Trouble Testing Set.

I find that for the busy electrician a testing set made from 4 dry cells and a buzzer mounted in a suitable box is a quicker and more convenient way of locating open or short circuits in a car lighting system than any expensive magneto. With the magneto, the electrician needs his helper for places where the clips won't grip, but with the buzzer box the electrician can work alone and the helper can be employed on other work.—J. G. Kopple, Elec. Supt. of Bridges, Sault Ste. Marie, Ontario, Canada.

General News Section

W. F. Minor

Mr. W. F. Minor has recently been appointed manager of the Holophane Works of the General Electric Co., to succeed Mr. V. R. Lansingh, who has been given charge of special development work.

Mr. Minor has been connected with the Holophane Works during practically all of his business career,

W. F. Minor.

and is known among his great circle of business friends from the East to the West coast as a remarkably successful sales manager, from which position he has has just been promoted. He is held in affectionate esteem by all of the salesmen and engineers of the Holophane Co., with whom he has been associated and his wide circle of friends, both business and personal, will be pleased to learn of his appointment.

Mr. Minor has made the following statement of the Holophane policy:

"I believe that no organization is truly successful unless it creates a product which is honestly useful, which makes people's lives easier to live and happier. And next to usefulness, I believe that the success of an organization depends upon promptness, accuracy, and square action in the daily details of its business. The aim of the Holophane Works is to produce reflectors that are a real solution to lighting problems, artistic or commercial, and at the time to carry on every day's business in the straightforward way that squares with an honest purpose. I believe that if we hold to this policy we shall deserve and will continue to receive the active personal support of the electrical engineers of the steam railroads of this country."

C. W. Bender on Train Lighting.

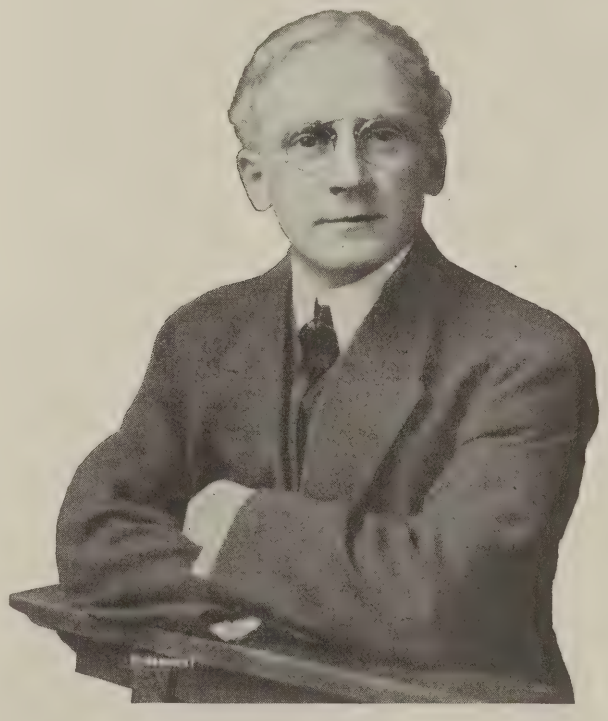
A recent issue of the *General Electric Review* contains a very extensive article on railway train lighting by Mr. C. W. Bender, manager, of the commercial department, National Lamp works, of the G. E. Co. He was for many years connected with the car lighting department of the Penn. R. R. so is particularly well qualified to write on this subject.

The head-end systems of the B. & O., C. M. & St. P. R. R., and Harriman Lines are all carefully described and well illustrated. The article then takes up axle generator systems, including the Consolidated type L, the Gould simplex system, the Safety, U. S. L. and Stone systems. This article is written with the viewpoint of giving the engineering profession in general an idea of the importance and difficult engineering features involved in railway car lighting work.

Bertram H. Smith

The many railroad friends of "Bert" Smith will be interested to learn that he has recently joined the forces of the Edison Storage Battery Co., with headquarters at San Francisco.

Mr. Smith has been in the battery game for many years; he was Secretary-Treasurer of the National Battery Co., in 1899, and later in the sales department of the same company up to the time that it went into the hands of a receiver in 1907, and was absorbed by the Cutler Hammer Co. In 1908, when the National



Bertram H. Smith.

and "Bliss" interests were taken over by the U. S L. Mr. Smith was made manager of the Chicago office, which position he held up until the end of the past year.

There is little of the U. S. that Bert hasn't trotted over in selling proxide of lead and here's wishing you the best of success, old boy, in disposing of an equal amount of proxide of iron and nickel hydrate.

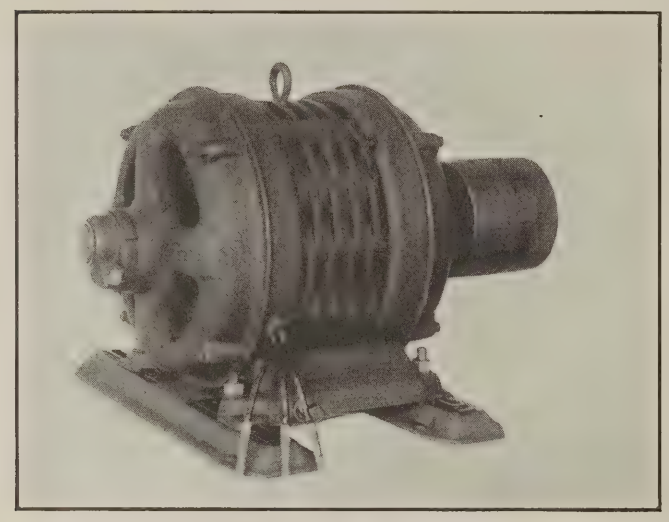
U. S. Light & Heating Co. Moves Offices to Niagara Falls.

The general offices of the United States Light & Heating Company at 30 Church street, New York City, will be moved on May 20, 1914, and located thereafter at the company's plant at Niagara Falls, N. Y.

This transfer will result in bringing together the administrative, sales, engineering and production departments and will insure the most effective conduct of all in the interests alike of patrons and stockholders.

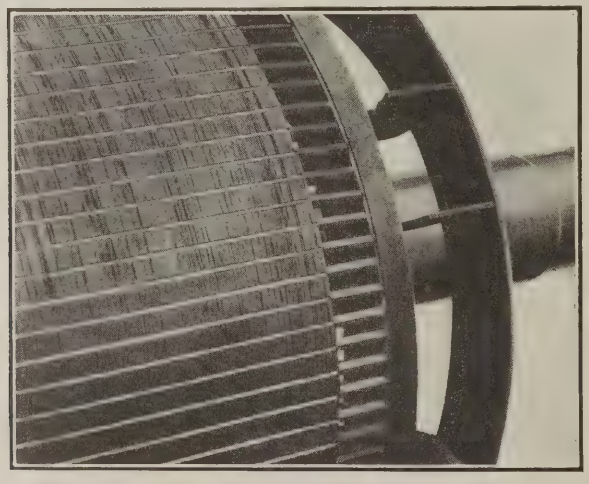
Induction Motor of New Design

The new Westinghouse line of squirrel cage induction motors possesses several noteworthy features. Among these are: The extensive use of pressed steel in their construction; rotors with cast-on short circuiting rings and moisture and heat resisting insulation; dust-proof bearings; high efficiency of operation.



New Westinghouse Induction Motor.

The use of pressed steel in motor construction represents a marked advance in motor design. It imparts great mechanical strength and is very uniform in structure. Hence a motor of a given weight can be made with more active material than motors of corresponding capacity in cast iron frames.



Enlarged View of Surface of the Armature.

In these motors, rolled steel forms the frames of the sizes above 20 H. P., and end plates of the smaller sizes (which are of the so-called frameless type,) and the feet and the slide rails of all sizes. As a result these motors are very compact, a feature that is of great importance in many applications.

Above 5 H. P., the form-wound stator coils are laid in open slots. Repairs in case of accident can be readily made.

The rotor construction is especially interesting. In all sizes, the rotor bars are insulated with a special cement which is moisture resisting and will withstand a high degree of heat and mechanical stress. In motors above 15 H. P., the bars are connected electrically and mechanically by casting the short-circuiting rings around their ends. Hence these rotors, having nothing that can burn out, deteriorate under heat, or work loose under vibration, are practically indestructible.

The bearings, being the only wearing part, have been designed very liberally. They are protected from dust by a cap on the front end and by felt washers between the metal rings on the pulley end.

The efficiency and power factor are high, not only at full loads but at fractional loads also. This last feature is of special importance because industrial motors generally run at less than full load.

These motors are being put on the market in all commercial sizes from 1 to 200 horsepower.

New High Efficiency Station Post Lighting Units

A new lighting unit to accommodate the new type "C" high efficiency Mazda lamps has recently been designed by the Holophane Works of the General Electric Company. There is a strong tendency at the present time to light the station approaches and environs with single light ornamental standards. However, as this unit is designed specially to accommodate the new Mazda lamps, it should be of special interest to railway lighting engineers.

New Unit.

There is a top reflector provided which is made of Pyro, a dense opal glass, and the lower part of the unit is a light opal glass with sufficient diffusive power to moderate the intense brilliancy of the new lamps.

As a result of this combination, the upper part of the unit acts as an ordinary reflector, giving a downward distribution, while the lower part of the unit diffuses the light properly. This unit is designed for using either the multiple or series type lamps of 750 watt size. This lamp without reflector gives a maximum candle power of 950 c. p. at an angle of about 65° from the nadir.

This unit is of an ornamental and a very pleasing appearance, and this fact combined with its high efficiency and ability to accommodate the new lamps, make it an ideal lighting unit for railroad station approaches.

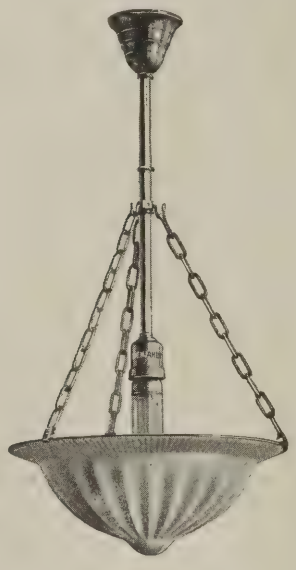
New Eye Comfort Bulletin.

The National X-Ray Reflector Co., of Chicago, Ill., have recently published a special architect's number of their house organ "Eye Comfort," which contains much information on the design and location of lighting equipment in various types of buildings. Indirect lighting is treated in a thorough manner in all the various modifications, as follows: cove lighting from cornices, general lighting from pedestals, wall bracket fixtures, silk shaded arc lamps, hanging bowls, urns, etc. The booket contains many practical suggestions and detailed design, much of which will interest the railway lighting engineer in designing station and office building illumination. Copy will be furnished upon request to any of our readers.

New Benjamin Fixtures for High Efficiency Lamps

The Benjamin Electric Manufacturing Co., of Chicago, have recently developed a complete line of fixtures to accommodate the new type "C" high efficiency Mazda lamps. This line as shown in the accompanying illustrations consists of both outdoor and indoor type units. Those shown in Figs 1 and 2 are indoor types although the Fig. 1 is equipped with special

1. Enclosing Globe Unit for Outdoor or Indoor Service.



2. Indirect Unit for Station or Office Lighting.

ventilation and weather proof features which makes it suitable for outdoor service. This unit consists of an opal diffusing bowl which has sufficient density to eliminate the glare of the high efficiency lamps. This unit is suitable for waiting rooms, office, etc.

The indirect unit in Fig. 2 consists of an enameled steel inverted reflector which is fluted in a decorative design which gives added diffusing surface; it is supported beneath the lamp by three chains. The lamp is hung vertically from the supporting stem. The high intrinsic brilliancy of the new lamp makes it undesirable to have any portion of the lamp filament come in the line of vision, so indirect lighting where the light source is entirely concealed, is particularly desirable with this lamp.

The fixtures shown in Figs. 3 and 4 are best suited for station platform, yard, shop and freight house service. The shallow bowl type of Fig. 4 should be used wherever the fixture can be mounted high above

3. Deep-Bowl Unit for Use Where Light Must Be Placed Low.

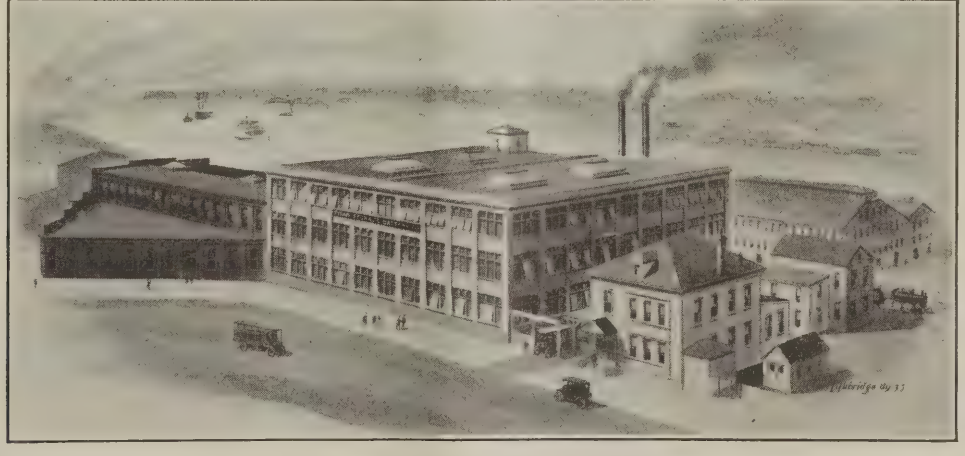
4. Shallow-Bowl Unit for Use Where Light Is Mounted High.

the floor so as to be out of the range of vision, and the deep bowl type of Fig. 3 should be used wherever it is necessary to place the lighting fixture only slightly above the line of vision.

New Titan Storage Battery Plant.

Battery men will be interested to learn of the change in name and location of the company which has heretofore done business as the Baltimore Electric Storage Battery Co., of Baltimore. On account of the necessity for increased manufacturing facilities and also because of the fact that Newark possesses certain advantages over what could be procured in Baltimore, the general offices and factory of this company have recently been removed to Newark. In order to avoid the identification of the company name with location, the name of the company has been changed to the Titan Storage Battery Co.

Extensive quarters have been secured in Newark, N. J., at Chapel St. and Lister Ave., and complete manufacturing equipment installed, which is turning out a large supply of batteries of all sizes for various purposes.



New Titan Storage Battery Plant.

The officers of the company are as follows:

Henry M. Keith, President; Daniel C. Spruance, Vice-President; Edward S. Hyde, Treasurer; Henry H. Hanson, Secretary. These gentlemen with Minor C. Keith and John G. Gray constitute the board of directors. Dr. W. E. Winship is General Manager, A. H. Mustard is Sales Manager, and Eugene Handler is Superintendent. No change in the policy of the former company, beyond that of enlargement and expansion of operations, is indicated by the change in name and location.

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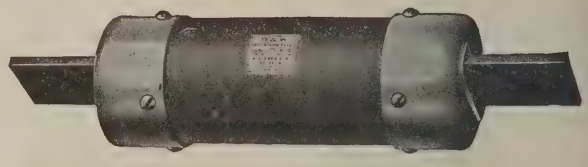

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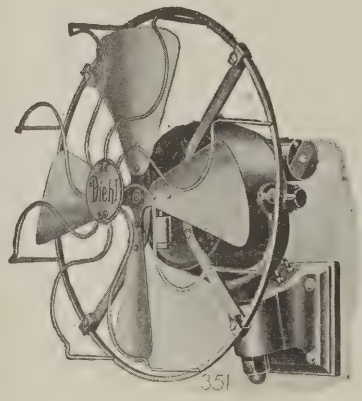

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Westinghouse Notes

The Westinghouse Electric & Mfg. Company has recently issued leaflets Nos. 3572 and 3660 covering the electrification of the New York Extension of the Pennsylvania Railroad, and the New Haven & Hartford Railroad respectively.

These leaflets cover the salient points of both roads together with a description of the apparatus used. These leaflets are well illustrated and contain maps showing the territory covered by both of the electrified systems.

Descriptive leaflet No. 3571 issued by the Westinghouse Electric & Mfg. Company, covers the commutating-pole rotary converters. This leaflet describes in some detail this type of converter, explaining its advantages with particular reference to the commutating pole and the method of starting. The details of construction are described at some length, and are clearly illustrated. Views of applications are also shown.

"Electric Arc Welding Processes" (Catalogue Section 3049), issued by the Industrial & Power Department of the Westinghouse Electric & Mfg. Company, is a reprint of an article recently appearing in the technical press by Mr. C. B. Auel, Director of Processes, Standards and Materials of the Westinghouse Company.

Descriptive Leaflet No. 3685, issued by the Westinghouse Electric & Mfg. Company, covers Type SK Direct Current Commutating Pole Generators from 1½ kw. to 200 kw., 125-250 volts.

These generators have rolled steel frames, commutating poles, and are characterized by excellent commutation, high efficiency, low operating temperature, and large overload capacity. The leaflet shows complete and detailed views of the construction, and describes the general features of the machine.

Novel Stunt of the Central Electric Co.

The Central Electric Company, of Chicago, have recently prepared a special war map showing the position of our forts and forces along the Mexico border and of our fleets in Mexican waters.

These maps are very interesting in view of the present Mexican situation. They are being sent out to the trade and will gladly be forwarded to any of our readers upon request to the Central Electric Company, Chicago.

Benjamin Electric Company Awarded Gold Medal.

The Benjamin Elec. Mfg. Co., were awarded the gold medal of the American Museum of Safety at the recent International Convention of Safety and Inspection, at New York, for the safety feature of their lamp grip and punch press devices. The former device has been described in the *Railway Electrical Engineer,* and the latter device consists of two levers, one at either side of the press, and before the punch can operate the operator's hands must be on both of these levers.

Ball Bearings for Line Shafting.

This is the subject of a new bulletin issued by the Hess-Bright Ball Bearing Mfg. Co., showing the detailed construction of hangers and mounting where ball bearings are applied in line shafting.

The booklet includes much information on prices, dimensions, and construction data, and will be of interest to master mechanics and other shop men. It may be had upon application to the Hess-Bright Mfg. Co., Philadelphia, Pa.

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Semi-Annual Convention will be held at Atlantic City, Friday, June 12th, Headquarters Hotel Dennis. Annual Convention October 19th to 23rd, at Chicago.

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RAILWAY ELECTRICAL ENGINEER

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Constant Voltage

AXLE LIGHTING SYSTEM

combines the SIMPLICITY of Straight Storage with the Flexibility of the Axle System

The E. S. B. System requires NO POLE CHANGER, NO LAMP REGULATOR. Pole Changer and Lamp Regulator TROUBLES are therefore wholly ELIMINATED

The Dynamo Field Control is affected with

NO MOVING PARTS — NO LEVERS — NO DASH POTS
NO VIBRATING CONTACTS — NO PIVOTS — NO CARBON PILES

The E. S. B. SYSTEM provides IDEAL CONDITIONS for MAXIMUM BATTERY LIFE

After 13 months of constant service, with a record of 195,608 miles, an examination of the batteries showed PLATES in PERFECT CONDITION, SEDIMENT only 1/4 inch.

The E. S. B. System Requires No Adjustment

for different load conditions, different schedules or different seasons. The following data are taken from the records of two E. S. B. Equipments, each covering one round trip between Chicago and Los Angeles—one installed on a chair car smoker and the other on a dining car.

	Ampere Hours	
	Chair Car	Dining Car
Generator Output	930	2,787
Battery Charge	303	397
Battery Discharge	236	321
Battery Overcharge	67	76

NOTE the difference in Generator Output, with NO difference in adjustment.

THE E. S. B. SUSPENSION carries the weight of the dynamo on *Two Bearings.* The wear is limited to two steel bushings and two steel pins, easily and cheaply renewed.

Special Bulletins on Request

THE ELECTRIC STORAGE BATTERY CO.

MANUFACTURER OF

The "Chloride Accumulator", The "Tudor Accumulator"
The "Exide", "Hycap-Exide", "Thin-Exide" and "Ironclad-Exide" Batteries

PHILADELPHIA, PA.

New York Boston Chicago
St. Louis Cleveland Atlanta Detroit

1888-1914

Denver San Francisco Seattle
Los Angeles Portland, Ore. Toronto

Successful Train Lighting

has always depended, in large measure, upon equipment cost and length of efficient service.

WILLARD
STORAGE BATTERIES

have contributed more than any one factor to the magnificent results secured from electric train lighting installations, from their earliest inception to the present day.

WILLARD STORAGE BATTERY COMPANY

CLEVELAND, OHIO

CHICAGO DETROIT INDIANAPOLIS SAN FRANCISCO NEW YORK

SAFETY FIRST

ECONOMY renewable cartridge FUSES

Use them wherever Safety is the first consideration and Economy next.

¶ Economy Renewable Cartridge Fuses never vent fire nor hold a sustained arc—they are absolutely safe.

¶ A large number of buyers of fuses have discarded the old-fashioned method of using non-renewable fuses and have standardized their electrical protective equipment by the exclusive use of Economy fuses—with the result of effecting a saving in annual fuse maintenance expense **of over 80%**.

SPECIAL ANNOUNCEMENT

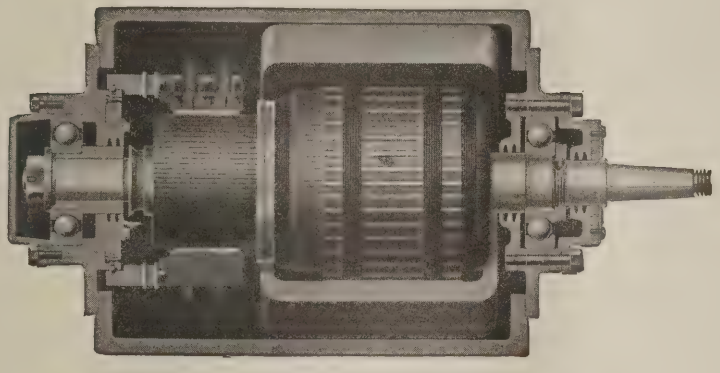
Two Economy Renewal Elements are now furnished (without charge) with each Economy Fuse. Now **you** figure what fuse is the cheapest, not only to buy but also to maintain.

Write for catalog and price list bulletin No. 4.

ECONOMY FUSE & MFG. CO., Kinzie & Orleans Sts., CHICAGO

Once in Six Months

is as often as axle generators mounted on **Hess-Bright Ball Bearings** need lubrication—how often do your plain bearings require inspection and lubrication?



The balls actually run in the grease, so there is no waste of lubricant. With

Hess-Bright Ball Bearings

failure is practically unheard of—how many times during the last year have you had equipments fail, due to bearing trouble?

Hess-Bright's can easily be applied to old equipment.

Let us send you our latest bulletin on Ball Bearings for Axle Generator Service.

The Hess-Bright Manufacturing Co.

MAIN OFFICE AND PLANT
Front St. and Erie Ave.
Philadelphia

STORES FOR RETAIL DISTRIBUTION
Philadelphia 666 N. Broad St.
New York 1974 Broadway
Chicago 1800 Michigan Ave.

Do you know what this emblem stands for?

IT means bigger, better, cleaner business. It is the inspiring insignia of 140 clubs, with a membership of over 10,000 earnest men. Learn what the Associated Advertising Clubs of America are doing for honesty in business; for more systematic, scientific and successful methods of distribution, advertising and salesmanship. Attend the Tenth Annual Convention of the A. A. C. of A.

TORONTO
JUNE 21-25, 1914

Interesting Program

The program for this great convention is comprehensive and diversified, covering every phase of modern merchandising. The sessions will be addressed by able, successful men; open meetings, devoted to a wide range of special topics, will give everybody a chance to ask questions and hear his own problems discussed by the men who have met and solved them.

Edward Mott Woolley

the famous writer on business topics, has made a study of the A. A. C. of A. and their work, as well as of the plans for the Toronto Convention. He has embodied the result in a little book, "The Story of Toronto". This book paints a graphic, inspiring picture of what this great movement signifies.

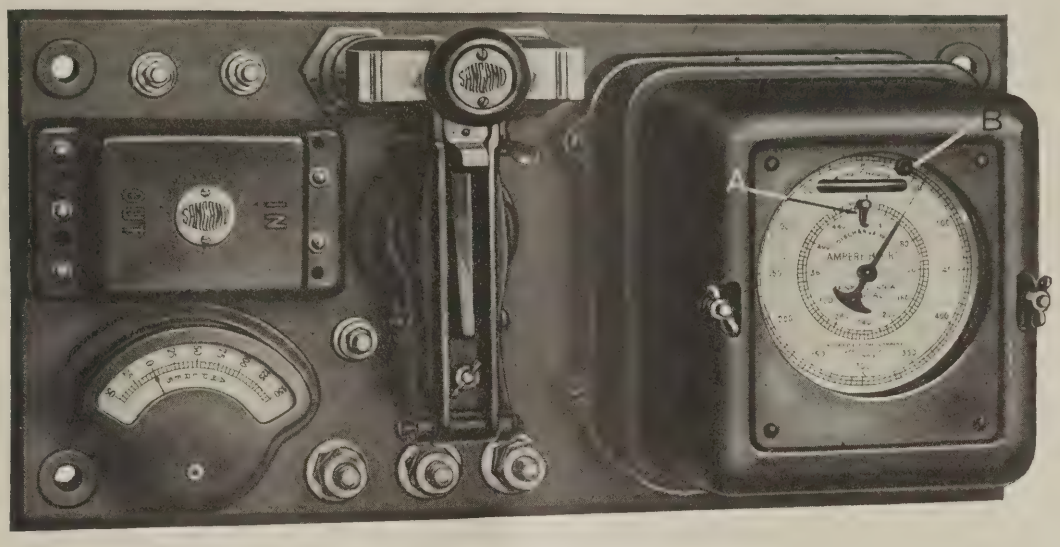
It will be sent free to all business men asking for it on their business stationery — together with detailed facts as to the convention program and rates for accommodations

Address

CONVENTION BUREAU

Associated Advertising Clubs of America

Toronto, Canada



Ampere Hour Meter Control Panel for Axle Equipments.

Like an Expert Battery Man on Every Car

Think of what it would mean in increasing battery life and decreasing maintenance costs if you could have a special attendant for every axle equipment, who, with untiring vigilance and with great accuracy, would record every ampere hour discharged from the battery and would control the operation of the generator so that just the proper amount of charge, to replace this discharge plus battery losses, measured in ampere hours, would be given the battery, but no more.

This is the service which the variable resistor type ampere hour meter will perform for you—it will operate with equal accuracy and reliability on any type of axle equipment or head end system. Isn't this worthy of a careful investigation by you?

Write Us for Further Information

SANGAMO METERS

BUILT LIKE A WATCH

SANGAMO ELECTRIC CO. SPRINGFIELD, ILLINOIS

Doric and Superlux

LIGHTING GLASSWARE
for
RAILROAD PURPOSES

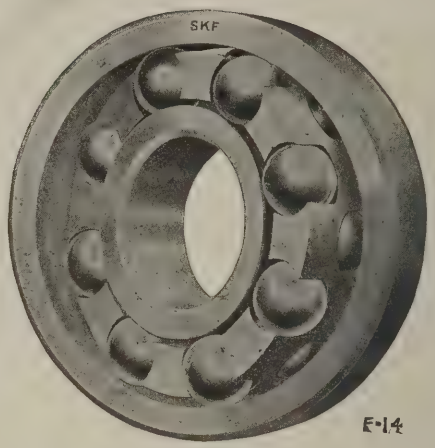
You will find what you want in our various lines of lighting glassware—together with our extensive equipment in the way of **lighting specialties**—just what you require for railroads, offices, stations, cars, shops, etc.

In DORIC Glassware we have a wide range of shades, bowls, dishes and hemispheres.

SUPERLUX—the Featherweight glass—is something absolutely new and different. It is a pure, white glass, very light in weight, made up in shades, reflectors, bowls and hemispheres.

Send for our new catalog on DORIC and SUPERLUX—including also our latest lighting specialties.

Lorin W. Young,
LIGHTING STUDIOS CO.
Madison Ave., Cor. 31st St.
NEW YORK



No. 412—Deflected Position

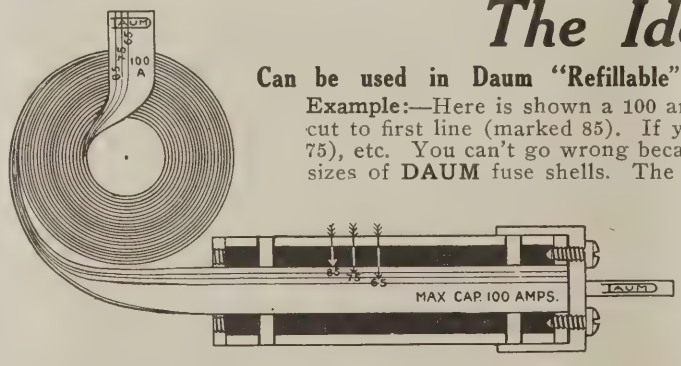
For Axle Lighting Generators
Specify No. 412 SKF Railway Type Ball Bearings

Self Aligning.
Two rows of one-inch balls, 16 in all.
One-piece retainer without rivets or rotating oiling devices.
Balls and races made of Swedish crucible steel.

Send for Bulletin No. 12.

SKF Ball Bearing Co.
50 Church St. **New York City**

SAFETY FIRST, LAST AND *ALL* THE TIME
The Ideal Fuse Strip



Can be used in Daum "Refillable" Fuses to give maximum protection at minimum cost

Example:—Here is shown a 100 ampere renewable fuse. If you want 85 amperes, you cut to first line (marked 85). If you want 75 amperes, you cut to second line (marked 75), etc. You can't go wrong because these fuse strips are made to fit only in different sizes of **DAUM** fuse shells. The capacity is marked on all fuses on inner end of fuse roll. You are never "up against it" with these fuses. You have "Safety First" and you can make your fuses anything under the safety limits. Can also supply fuses in rolls up to 600 amperes. **Prices on request.**

A. F. DAUM COMPANY
Sole Manufacturers **Pittsburgh, Pa.**

A. B. C. Car Lighting Lessons

For $1.00 enclosed please send me the A. B. C. Car Lighting Lessons covering the first two years of the course, Penn R. R. School of Electricity, etc.

Name .....

Position ..... R. R. .....

Mailing Address .....

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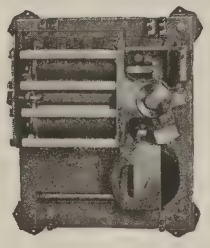
Laborers and Tradesmen

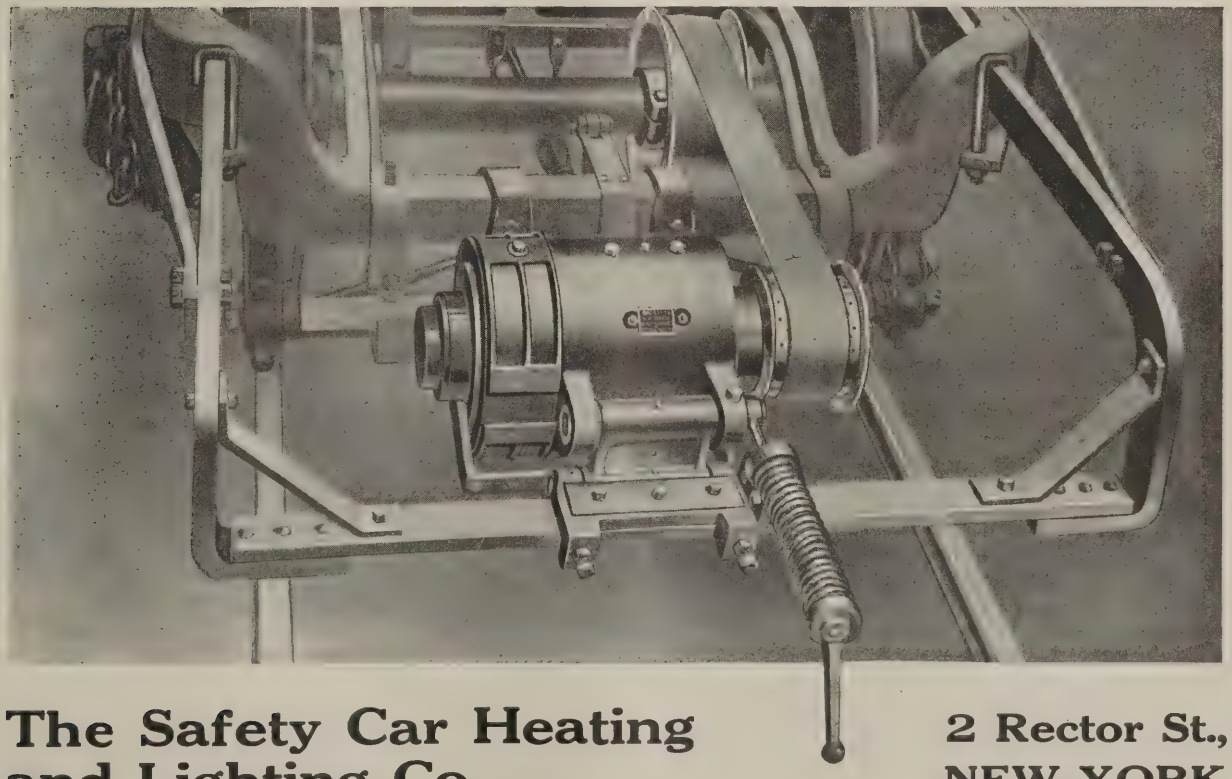
For all classes of work supplied to employers, free of charge, one man or a train load of men; pay own railroad fare to your work. Wire or 'phone Franklin 3529.

DIAMOND LABOR SUPPLY CO.
32 S. CANAL ST. **CHICAGO, ILL.**

Safety Electric Light.

We are responsible for railway car lighting throughout. We designed and developed the lighting fixtures and the axle lighting equipment, generator, generator suspension, regulation, etc.





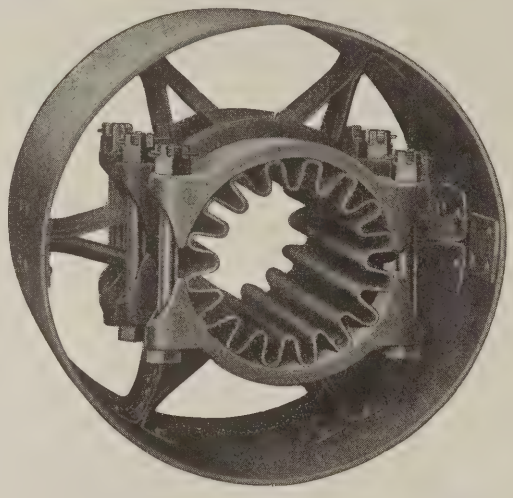
The Safety Car Heating and Lighting Co.,

2 Rector St., NEW YORK

KEYSTONE
Railroad Axle Pulley

MANY THOUSANDS IN USE

Looks Good, Don't It?

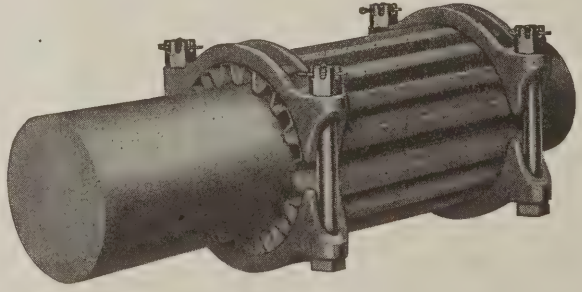


Keystone Railroad Pulley With Oneida Corrugated Bushing
Patented January 8, 1907

The Keystone Pulley with Oneida steel Corrugated Bushing

is the best combination for car axle lighting on the market.

Pulley made flange or flangeless. Standard 7½-in. bore, 16-in. to 23-in. diameter inclusive. Write for booklet.



Oneida Corrugated Steel Bushing Made to Fit Straight or Taper Axle
Patented January 8, 1907

Oneida Steel Pulley Co.
ONEIDA, N. Y.

The Originators of Steel Railroad Pulleys and Steel Corrugated Bushings

"Why Is a Conduit"?

(Continued from article in last issue.)

"Safety First" should be provided in *Car Wiring.* Rust in the conduit system destroys the insulation on the wires and results in future trouble.

How annoying to the traveling public to be left in darkness when there should be illumination, and to the company to lose the use of the car while the shop men are having all sorts of trouble tearing things to pieces generally to get at the corroded material and replace it.

A *good* Galvanic protection is necessary. *Not* the sort that is applied on the tonnage basis, where there is always a tendency to speed-up and a product lacking uniformity results. "A chain is only as strong as its weakest link."

"Galvanite" Conduit

has been produced by scientific co-operation with leading engineers who desired to insure, without greatly increased cost, more permanent installations than those provided by many commercial conduit.

"Spellerized" steel pipe scientifically treated by our electrolytic process acquires two protective coatings, one being an alloy of zinc and iron, and the other a sheet of hard pure zinc over the alloy. These two are blended into one homogeneous continuous covering, which is very tenacious to the pipe, for it is impregnated thereon. The hard surface of this conduit resists abrasion and protects the pipe by *effective* galvanic action. Thus you obtain

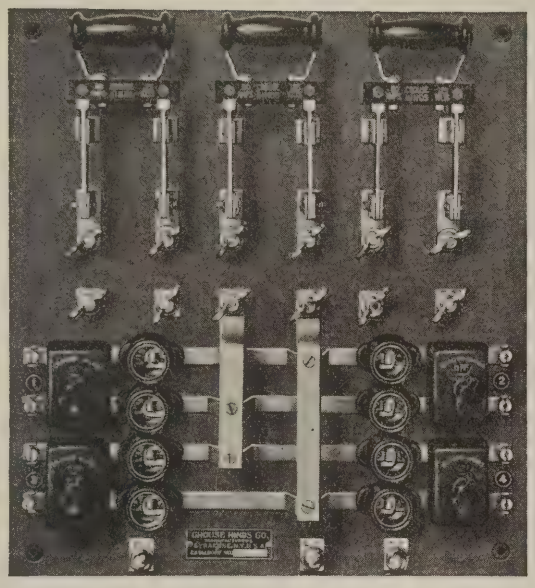
A Permanent Raceway for Wires

(A purely technical paper, "Why Is a Conduit?" giving more detailed information of value to engineers than it is possible to compress into a series of ads, will be promptly mailed on request.)

The American Conduit Mfg. Co.
PITTSBURGH, PA.

"DO IT ELECTRICALLY"

Send Us Your Car Panelboard Specifications



Front View of Panelboard Designed and Built by Us and Adopted by One of the Nation's Large Railway Systems as Standard for the Purpose.

We Design Panels for any System of Car Lighting, and Submit Drawings Free of Charge.

Specifications Accurately Followed. Material and Finish, the Very Best. Delivery, Strictly According to Contract.

Panelboards As and When you want them

The unsuitability of porcelain cut-outs to car service is now generally recognized, and panelboards, with the strength, rigid connections and conveniences lacking in porcelain cut-outs, are regarded as a regular part of the up-to-date car's electrical equipment.

Because of the many designs of cars and different lighting systems, however, no one design of panel has become standard, and for each separate condition a special form of construction is desirable.

For twenty years we have been leaders in the panelboard field, and in all respects our equipment—engineering and construction departments—have been kept at the highest obtainable point of efficiency.

This record and present position make it possible for us to meet promptly and exactly the requirements for car panelboards of every description.

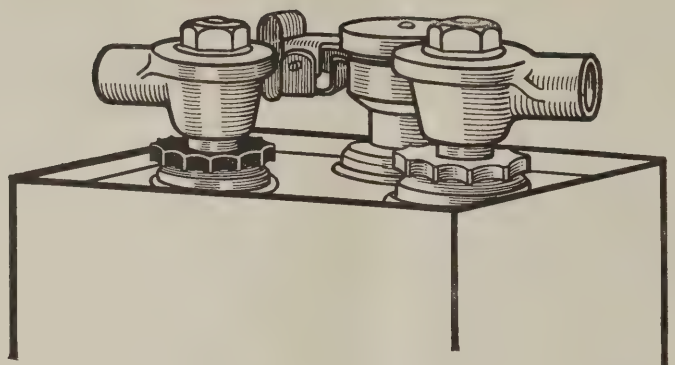
Full lines of standard panels are shown in Bulletin No. 1. Copies mailed free upon request.

Test Our Ability to Serve You

Crouse-Hinds Company

Syracuse, N. Y., U. S. A.

NEW YORK	BOSTON	CINCINNATI	CHICAGO
30 Church Street	201 Devonshire St.	1-7 Fourth St., W.	417 S. Dearborn St.



Edison for Service All the Time

With its steel container non-corrosive electrolyte and nickel-plated steel grids and pockets there is nothing about the Edison Train-lighting Batteries to break, fall apart, buckle, sulphate or *give trouble*.

Read Bulletin No. 1018

THE EDISON NICKEL-IRON-ALKALINE Guaranteed Battery

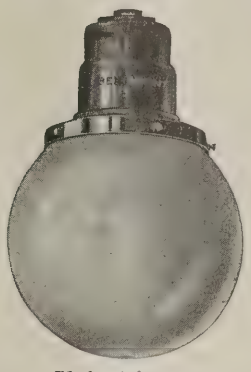
Made by the

Edison Storage Battery Co.

120 Lakeside Ave., Orange, N. J.

For The New High Efficiency Type "C" Mazda Lamps

Shallow Bowl Reflector — Best adapted for use in station platforms, for machine tools, etc., where a certain amount of concentration of light is desired. This unit is well ventilated.



Alabaster Globe Fixture—For either outdoor or indoor service. Is provided with special ventilation which prevents the entrance of rain or snow.

Deep Bowl Reflector—Protects the eye from the high efficiency lamp filament. Specially designed for indoor service where general illumination is desired. Hood is securely attached before enameling.

Have you noticed how "BENJAMIN" is always first and foremost in the development of lighting specialties?

BENJAMIN ELECTRIC MANUFACTURING CO.

NEW YORK
114 LIBERTY ST.

128 S. SANGAMON ST., CHICAGO

SAN FRANCISCO
RIALTO BLDG.

GOODRICH
AXLE-LIGHTING BELT

Now furnished for

75%

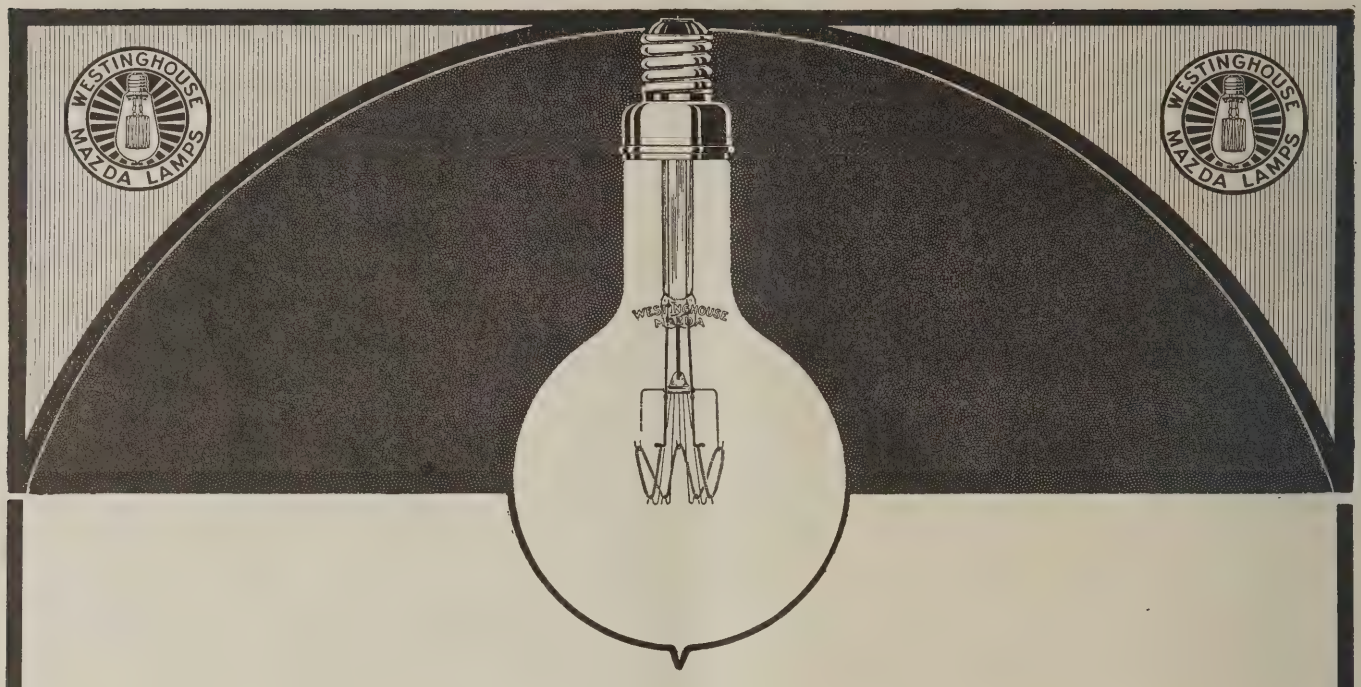
of the axle-generated lighting equipment of the country.

We have everything else in rubber supplies for the Railway Electrical Engineer

There is nothing in Goodrich Advertising that isn't in Goodrich Goods

The B. F. Goodrich Company
Factories: Akron, Ohio.
Branches in All Principal Cities

Makers of Goodrich Tires and Everything that's Best in Rubber



Use Big, New Mazda Lamps to Reduce the Cost of Lighting Your Stations, Shops and Yards

The New 750 and 1000 Watt Westinghoure Mazda Lamps enable you to get the benefit of the simplicity and reliability of the incandescent system at an operating cost much below that of other systems.

They require no special attention which reduces the maintenance cost to a minimum.

They give you light of the finest quality which means better work and more satisfied workmen.

They are "WESTINGHOUSE" Lamps which insures the successful and dependable operation of your system.

In other words, the new Westinghouse Mazdas will bring the lighting of your shops and yards a step nearer 100% efficiency.

Our bulletin gives information in detail. Send for it.

"Guaranteed by the Name"

Westinghouse Lamp Company

Offices Throughout the Country

Factories: Bloomfield, N. J., New York, N. Y.
General Offices: 1261 Broadway, New York, N. Y.

Repairing a broken locomotive frame by means of the

Westinghouse Electric Arc Welding Process

The illustration shows the finished weld in white. It is 3 inches high, 4½ inches wide and 4 inches deep. It required one man about five hours to finish the job, including cutting out the notch and filling in as shown, and when completed a smooth surface was formed that needed no chipping.

The convenience of such an outfit and the immense savings in time and money it affords are obvious from this example.

But Westinghouse Electric Arc Welding Outfits are as useful for many other classes of work, such as flue welding, fire-box and boiler repairs, filling up blow holes in defective castings, and other repairing, welding and cutting operations.

These outfits were not placed on the market until eight years of practical experience with arc welding in its Works showed the Westinghouse Electric & Mfg. Company how to design and construct welding apparatus that would be simple, reliable and economical in the highest degree. Many railroads are now using them.

You can probably install no device in your shop that will effect greater economies. Send for complete information.

Westinghouse Electric & Manufacturing Company

East Pittsburgh, Pa.

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
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Boston, Mass.
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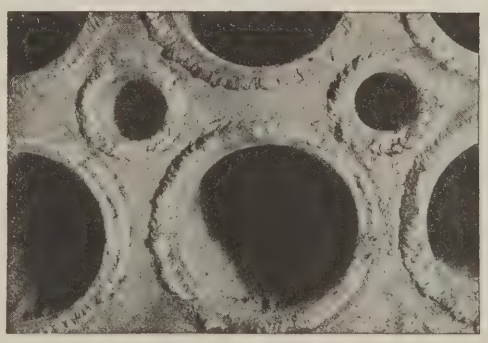
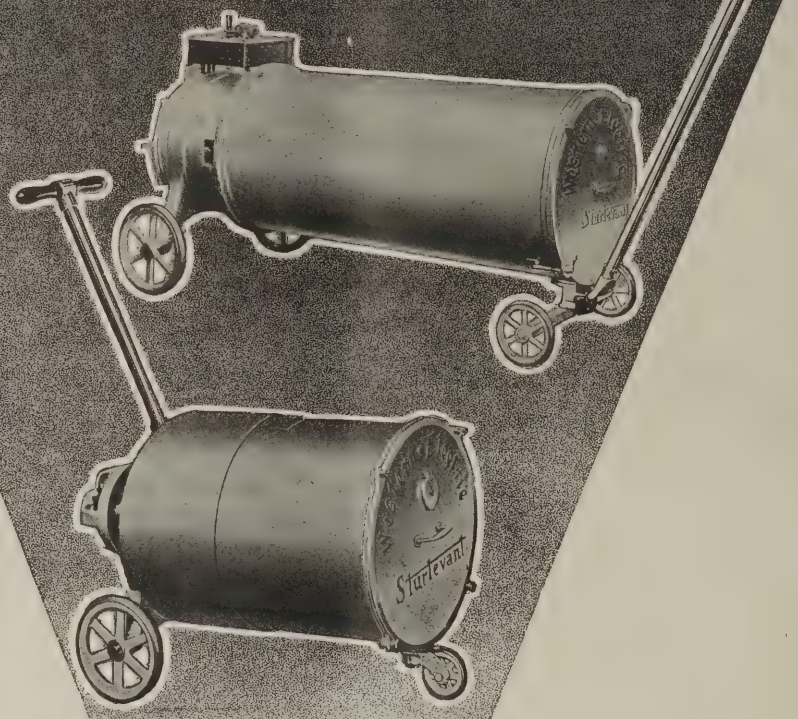


Electrically-Welded Flues.
The above illustration was taken from the report of the Committee on Design, Construction, and Inspection of Boilers to the A. R. M. M. A., 1913 (Circular CC, page 7). In this report the electric welding of flues was unqualifiedly recommended because of its great economy and because maintenance expense is practically eliminated.

Western Electric
Sturtevant
Vacuum Cleaners



The Clean and Only Way to Clean Cars

These Western Electric Sturtevant Vacuum Cleaners are simplicity itself. The only moving part is the specially designed fan balanced and mounted on the sturdy shaft of the motor. The best ball bearings made, insure easy running.

Everything for efficiency and nothing for repairs. There is a size either portable or stationary for every need.

Send to our nearest house for a copy of our illustrated booklet "Cleanliness Pays Cash."

WESTERN ELECTRIC COMPANY

Manufacturers of the 7,000,000 "Bell" Telephones

New York	Atlanta	Chicago	Kansas City	San Francisco	Montreal	London
Boston	Savannah	Milwaukee	Oklahoma City	Oakland	Toronto	Antwerp
Philadelphia	Richmond	Cincinnati	Denver	Portland	Winnipeg	Berlin
Pittsburg	St. Louis	Indianapolis	Omaha	Seattle	Calgary	Paris
Buffalo	Dallas	Minneapolis	Salt Lake City	Vancouver	Johannesburg	Rome
Cleveland	Houston	St. Paul	Los Angeles	Edmonton	Sydney	Tokyo

EQUIPMENT FOR EVERY ELECTRICAL NEED

750 and 1,000-watt National Quality MAZDA lamp. Maximum dimensions—length over all, 13½ inches; diameter, 7 inches.

Have Better Lighted Station Approaches at Lower Cost

with

750 and 1000-Watt National MAZDA Lamps

You can make a big cut in your annual lighting costs by adopting these new high-efficiency units in the lighting of all large areas—exterior and interior. For an equivalent amount of current used they give almost twice the light of the smaller types of MAZDA lamps.

The 750 and 1,000-watt National MAZDA lamps offer a quick and economical solution to the lighting of concourses, platforms, train sheds, yards and warehouses. They furnish a white steady illumination with maintenance attention reduced to a minimum.

A complete line of enclosing globes and reflectors have been developed for use with these powerful lamps by the Holophane Works of General Electric Company.

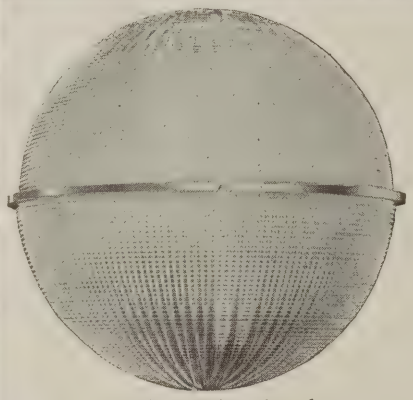
For more information write for a copy of our Bulletin 13D—just off the press.

Single lamp ornamental street standard.

NATIONAL LAMP WORKS
OF GENERAL ELECTRIC CO.

Nela Park, Cleveland

Member Society for Electrical Development: "DO IT ELECTRICALLY"



Holophane prismatic sphere No. 2030 used in new station shown above.

Good Light Makes Pleasant Waiting

Here's a passenger station waiting room—bright and cheerful—that takes the irksomeness out of the long after-dark wait. It's the illumination that's responsible.

Notice how evenly the light is distributed, how well diffused. There are no dark corners, no heavy shadows, no glare.

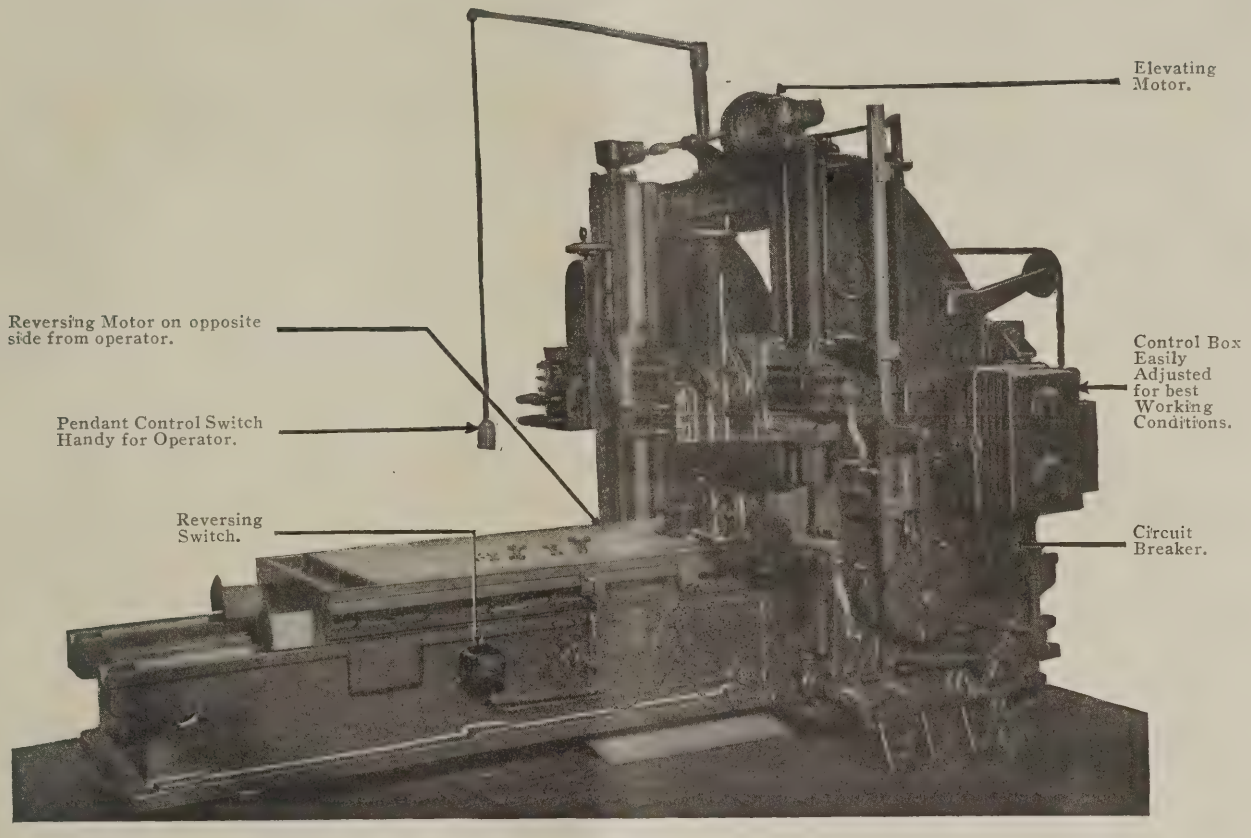
Holophane prismatic spheres were chosen for the lighting of this well appointed station for a double reason—for their beauty, their high efficiency. If translucent or opal glass had been preferred we would have recommended our beautiful Druid glassware—or perhaps Veluria or Sudan. All of these have a richness in tone and quality seen in no other glassware.

Write for full information concerning our special self-ventilating units for use with the new 750 and 1000-watt MAZDA lamps,

HOLOPHANE WORKS
OF GENERAL ELECTRIC COMPANY
CLEVELAND SIXTH CITY

New York Boston Philadelphia Chicago St. Louis San Francisco

Member Society for Electrical Development—"Do It Electrically"


Elevating Motor.
Reversing Motor on opposite side from operator.
Pendant Control Switch Handy for Operator.
Reversing Switch.
Control Box Easily Adjusted for best Working Conditions.
Circuit Breaker.

Most Economical Planer Drive

The G-E reversing motor equipment for slotters and planers is vastly more economical in operation and upkeep than any other existing drive.

Besides giving more product at less power cost this drive has the following features which are worthy of your serious consideration:

Maximum cutting speed always sustained giving greatly increased production.

Reverses remarkably close to a line.

Standard motor speeds 250-1000 r.p.m.

Many speed combinations, allowing slowest cutting and highest return speed to be combined.

Freedom from shocks, giving quickest reversals possible without jar.

Unexpected return of current to wires always finds motor and control apparatus ready to receive it.

Quiet operation.

Sparkless commutation.

Control in easy reach of operator.

This equipment is conservatively rated and has ample power. Investigate the power-rating of the motor you buy.

General Electric Company

Largest Electrical Manufacturer in the World

General Office: Schenectady, N. Y.

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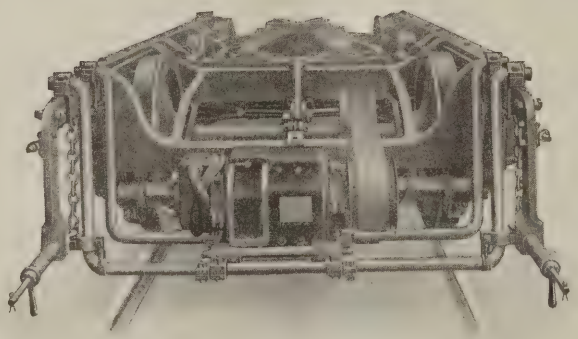

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OLIVER BATTERY CONNECTORS

THE LIFE OF A BATTERY CONNECTOR IS DIRECTLY PROPORTIONAL TO THE CARE WITH WHICH IT IS DESIGNED AND MANUFACTURED.

CRACKED OR POROUS LEAD OR BLOWHOLES ALLOW THE ACID TO CREEP INSIDE AND ATTACK THE BRASS STUD AND NUT AND COPPER WIRE.

THE ACID RESISTING RUBBER COVERING ON THE WIRE SHOULD BE THOROUGHLY IMBEDDED IN THE LEAD SHEATH OF THE STUD, THE WIRE BEING SOLDERED INTO THE STUD, FORMING A CONTINUOUS PATH FOR THE CURRENT.

THERE SHOULD BE A BRASS NUT ENCASED IN THE LEAD NUT SO THAT IT CAN BE DRAWN UP TIGHT WITHOUT STRIPPING THE NUT THREAD.

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THE FACE OF THE STUD AND NUT SHOULD BE RIDGED.

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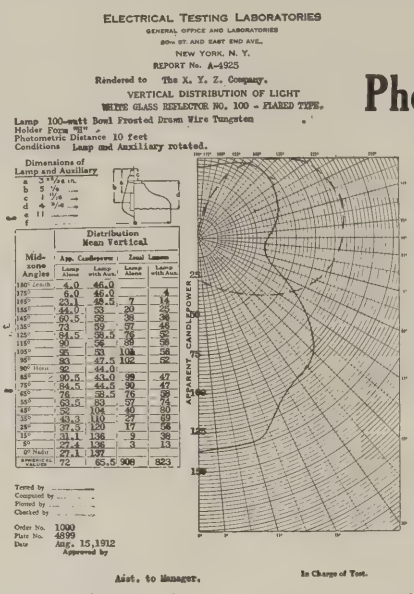
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Lamp 100-watt Bowl Frosted Drawn Wire Tungsten
Holder Form
Photometric Distance 10 feet
Conditions Lamp and Auxiliary rotated.
Dimensions of Lamp and Auxiliary
a 5 11/64 in.
b 5 1/8 "
c 1 7/8 "
d 4 3/4 "
e 11 "
f " "
Distribution Mean Vertical
Mid-zone Angles | Lamp Alone | Lamp with Aux. | Lamp Alone | Lamp with Aux.
180° (nadir) 4.0 46.0
175° 6.0 46.0 4
165° 23.5 58.5 7 14
155° 44.0 83 20 25
145° 60.5 98 38 36
135° 73 99 57 46
125° 84.5 98.5 76 52
115° 90 94 88 58
105° 95 93 100 58
95° 93 47.5 102 62
90° (Horiz.) 92 44.0
85° 90.5 43.0 99 47
75° 84.5 44.5 90 47
65° 78 53.5 76 39
55° 63.5 83 57 74
45° 52 104 40 60
35° 43.3 110 29 69
25° 37.3 120 17 58
15° 31.1 126 9 58
5° 27.4 136 3 13
0° (Nadir) 27.1 137
SPHERICAL VALUES 72 65.5 908 823
Tested by
Computed by
Plotted by
Checked by
Order No. 1090
Plate No. 4899
Date Aug. 15, 1912
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Asst. to Manager. In Charge of Test.
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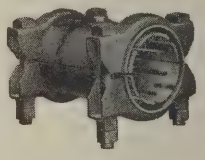

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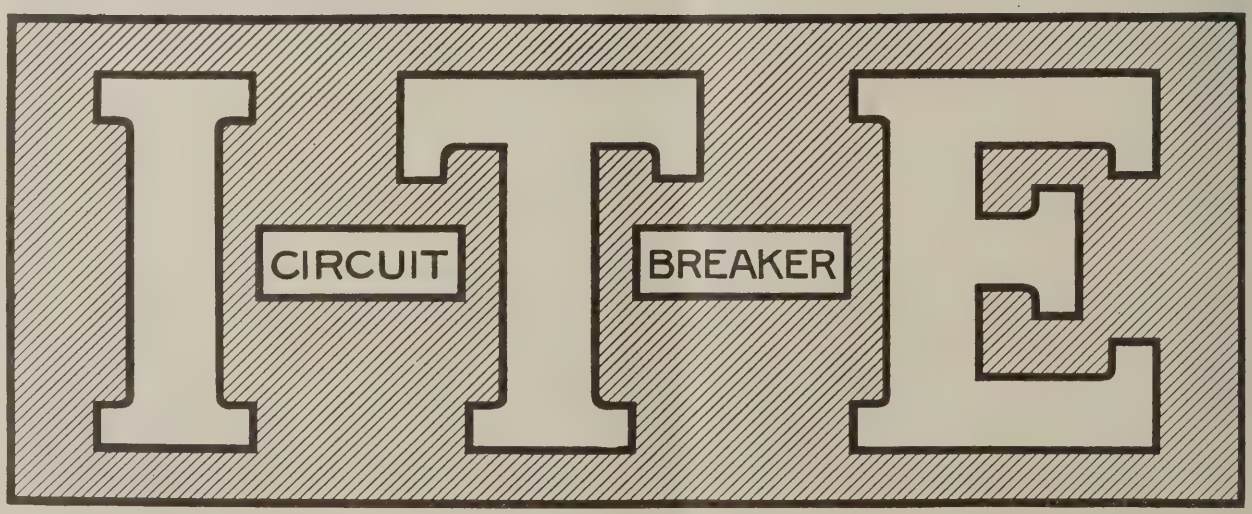

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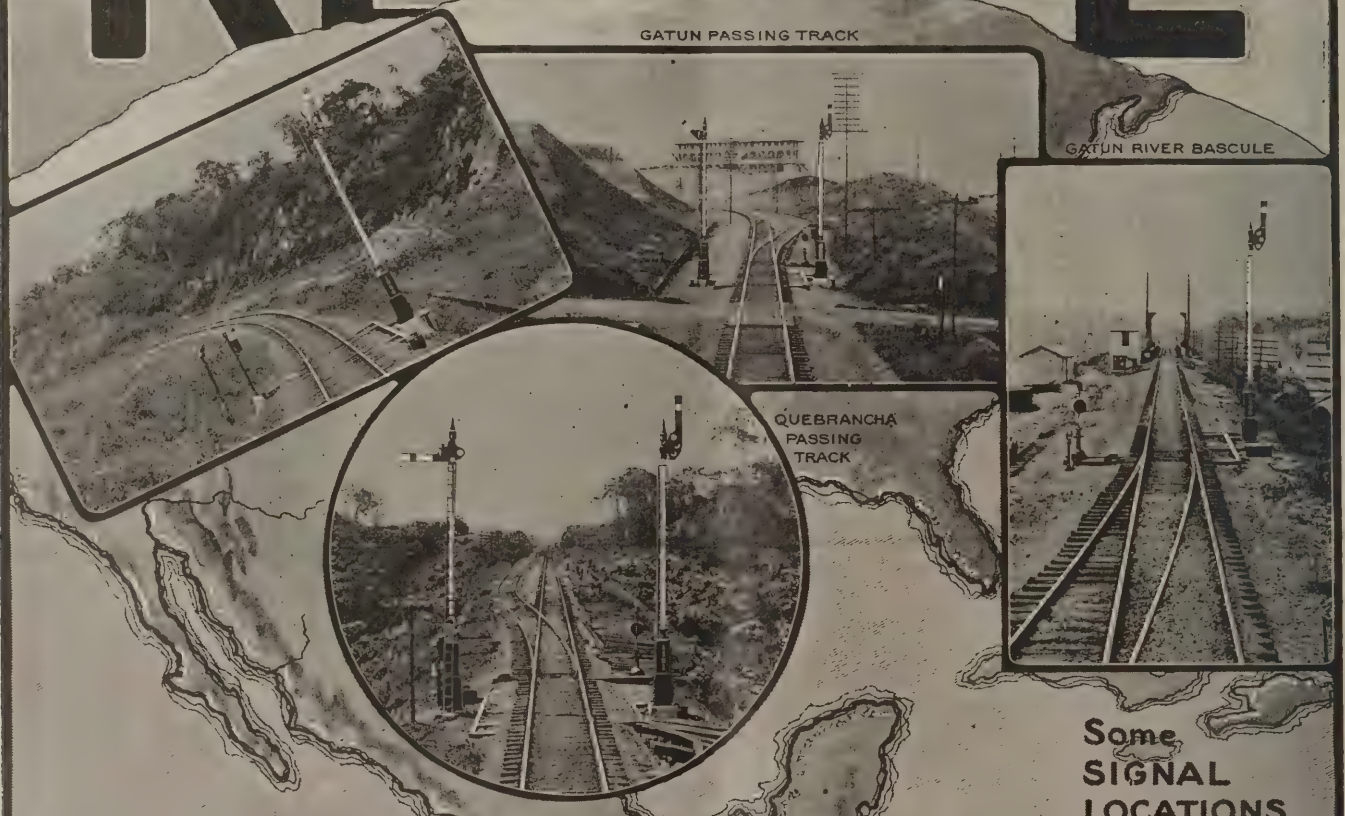

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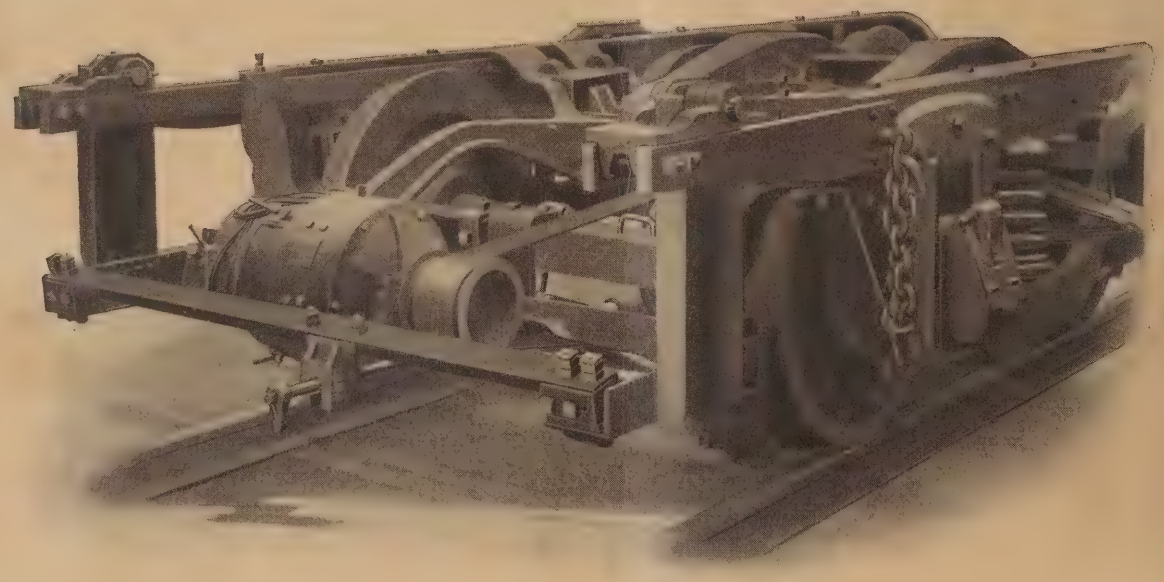

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